THE RECOVERY OF DISCRIMINATIVE SENSATION AFTER A STROKE IN THE ELDERLY

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ABSTRACT

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Thirty-one patients who had suffered a stroke which caused varying degrees of impairment of discriminative sensation were serially tested for stereognosis and 7 other modalities of sensation. Each patient was regularly tested from the time of onset of the stroke until recovery had taken place if this was within one year and for no longer than one year in the absence of full recovery. The patterns of recovery of discriminative sensation were defined. An attempt was made to determine the effect of loss of discriminative sensation on the functional outcome of rehabilitation.

The main findings were as follows:

1. Discriminative sensory loss at the onset of a stroke was associated with a poor prognosis for eventual functional outcome and a lengthened stay in hospital. The greater the sensory loss the poorer the chances of recovery and the greater the likelihood of a further stroke or death.
2. Persistent loss of discriminative sensation, in particular two point discrimination, was associated with a poor prognosis for eventual functional outcome. Once a particular level of function had been achieved, this was maintained after discharge from hospital in spite of the degree of sensory loss.

3. Recovery of discriminative sensation was most marked during the first three months following the stroke. The ability to discriminate tickle and texture recovered first whereas two point discrimination was always last to return. In a partial impairment of discriminative sensation tickle and texture and the ability to appreciate size were the modalities most often spared. These modalities together with proprioception were most likely to recover in those patients with initial gross impairment of sensation.

4. Stereognosis was shown to depend on cortical function. It was found that stereognosis may be intact with only 4 modalities present and may not when there are as many as 7. Stereognosis did not appear to be dependent on proprioception or two point discrimination.

5. An inexplicable loss of two point discrimination in the unaffected hand at the time of admission was sometimes found. Its recovery paralleled that of tickle and texture in the affected hand.

I HEREBY DECLARE THAT THE COMPOSITION OF THIS THESIS AND THE WORK DESCRIBED THEREIN HAS BEEN PERFORMED EXCLUSIVELY BY ME. THE THESIS HAS BEEN SPECIALLY WRITTEN FOR THE DEGREE OF DOCTOR OF MEDICINE AND HAS NOT BEEN SUBMITTED FOR ANY OTHER DEGREE, DIPLOMA OR PROFESSIONAL QUALIFICATION.

C O N T E N T S

CHAPTER 1

INTRODUCTION

INTRODUCTION

Man's sensory system enables him to adapt and relate to his environment. Different sensations are dependent on the stimulation of specific sensory end receptors which send impulses via spinal nerves and the spinal cord to the brain. Most afferent impulses entering the sensory system in this way are conveyed to centres which do not function at a conscious level; but the remainder, relayed to the sensory cortex, require a cortical element in their interpretation.

This cortical component is a special function of the parietal lobes which synthesise, correlate, integrate and interpret the primary sensory impulses. Proprioceptive fibres also terminate in the parietal lobes and the integration of this information with that of tactile discrimination results in the highly discriminatory faculty of stereognosis. Two point discrimination is also a complex sensation which requires a high degree of cortical interpretation and this is also a function of the parietal lobes.

It follows therefore that after a stroke, when there is damage to the brain, there may be a decrease in the ability to recognise sensory stimuli.

There has been much argument over the nature of astereognosis. Critchley (1962) in his review of the

subject found that a major problem was the lack of uniformity in terminology and methods of examination by other investigators. The main controversy centred on whether astereognosis was a modality specific disorder which could occur in the presence of intact sensation, but both Critchley and Semmes (1965) came to the conclusion that if looked for carefully, there was always some other sensory defect present.

By common usage and practice, the term stereognosis is taken to mean the ability to recognise common objects by feeling them, but some theorists do not accept this and say that in the purest sense of the word, it is only the discrimination of size, shape and form (Holmes, 1927; Roland, 1976). The first definition is the one adopted in this investigation.

In the normal person, the recognition of objects is an instant phenomenon, but can be considered as happening in two stages. The first is the recognition at a cortical level of the qualities of an object and it is logical to assume that the ability to feel light touch must be present before the other tactile sensations can be appreciated, i.e. the ability to discriminate texture, size, weight in the supported hand, shape (two dimensional), form (three dimensional) and two point discrimination itself. Proprioception would also appear to be essential for the appreciation of size, form and

weight in the unsupported hand.

The second stage depends on the ability of the cortex to relate and integrate all the sensory information in what appears to be a highly complex associational process leading to the identification of objects.

Review of the Literature

In the literature reviewed to date, there is little reference to the spontaneous recovery or otherwise of sensory impairment after a stroke. Many authors stress the adverse effects of sensory impairment on the rehabilitation of the stroke patient but do not support this with a detailed account of sensory recovery.

Buskirk and Webster (1955) studied the sensory modalities of pain, vibration sense and two point discrimination in 35 hemiplegic patients with ages ranging from 31-76 years. They correlated persistent sensory loss with a poor functional prognosis and prolonged hospital stay, but the patients were only studied from the time they entered hospital for a period of rehabilitation which did not necessarily coincide with the onset of the stroke. In fact, the duration of the stroke at the start of their study varied from nine days to seven years. Two point discrimination was the only cortical sensory modality tested which was never lost on its own, prognosis for outcome was worse if the loss persisted and

recovery, if it took place, had done so by one and a half months.

Newman (1972) followed the neurological recovery of 39 stroke patients with hemiplegia admitted to a rehabilitation unit within four weeks of the onset of the stroke. He included tests for two point discrimination and position sense in his assessment but there was no reference as to the suitability of these patients for sensory testing. As 19 out of the 25 patients with right hemiplegias had language problems and an unspecified number had some degree of mental impairment, obviously not all of the group would be able to co-operate reliably in the two tests for sensation that he described. However, he stated that in those who recovered the 2 modalities, recovery took place during the second and third month with very little occurring after that time.

A series of hemiplegic patients were followed throughout one year from one week post-stroke by Fugl-Meyer et al (1975), and included in the system of evaluation of motor function were tests for the sensory qualities of light touch and position sense. No correlation was found between these sensory modalities and the motor recovery of individual patients but it was admitted that the sensory measurements could not be evaluated when co-operation was poor and aphasia was present. However he did state that in the patients with a sensory deficit in

these 2 modalities, one third had achieved normality in two months and a further third by six months.

Corkin et al (1970) studied the sensory modalities of proprioception, pressure sensitivity, point localization and object recognition in patients who had undergone surgery for the relief of focal epilepsy. In some of these patients a follow-up examination was made of these modalities, this taking place as much as seven to twenty-eight years after surgery. They related any recovery which had taken place to the site of the lesion. Excisions in the post central gyrus were associated with persistent sensory loss whereas those in the rest of the parietal lobe were associated with transient loss. Though these studies were carried out in patients with cerebral lesions of varying aetiology, the findings may well be applicable to the patient who has had a stroke.

When the effect of sensory impairment on the outcome of rehabilitation of the stroke patient is considered, there are markedly divergent views. The reason for this would appear to be due to the populations of stroke patients under investigation differing in such respects as age, severity of stroke, interval from onset of the stroke to admission to rehabilitation unit, other medical factors, etc. Also, there is frequently no clear definition as to what constitutes sensory loss and unless the writer specifically describes the tests and their

purpose, then it has to be assumed that perhaps all that is being assessed is light touch, pain and vibration sense.

Marquardsen (1969) found that loss of sensation of a cortical type on admission had no bearing on the final outcome of rehabilitation. Feigenson et al (1977) supported this view in their study of factors influencing outcome and length of stay but did not define their tests for sensation referring only to "hemisensory loss". On the other hand, Hurwitz (1966) and Adams (1966) both emphasised the adverse effect that loss of discriminative sensation had on the rehabilitation of patients who had had a stroke and Stern et al (1971) showed conclusively in his study group that the poorest outcome was in those with a loss of two point discrimination, vibration sense and also a visual field defect, in addition to their hemiplegia.

There was therefore a lack of knowledge about loss of discriminative sensation after a stroke and the following questions required an answer:

1. Was there any pattern to the recovery of discriminative sensation after a stroke?
2. Did the loss on admission or persistent loss of discriminative sensation have any relationship to the eventual outcome of rehabilitation and the length of stay in hospital?

3. What were the results of carrying out the tests on a random sample of a non-demented, non-stroke population over the age of 65 years?

It must be emphasized that this investigation is a piece of descriptive research which involved the detailed testing at intervals of certain types of sensation in patients after stroke.

CHAPTER 2

NEUROANATOMY OF SENSATION

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Discriminative sensation is complex and involves the integration and interpretation of many different sensory impulses in the cortex. There are still large gaps in our knowledge about the structure and function of sensory receptors and the pathways transmitting sensory impulses.

The pathways of tactile and proprioceptive information start in the sensory receptors in the skin, subcutaneous tissues, muscles, tendons, ligaments and joints. These specialized end organs are anatomically different and are generally agreed to be specific for individual types of sensation. Tactile receptors for example, may be free nerve endings, networks of nerve terminals around hair follicles or various tactile corpuscles in the skin. Proprioceptive receptors are either muscle spindles or encapsulated structures in the tendons called golgi tendon organs. The sensation of deep pressure is transmitted by Pacinian corpuscles.

The cell bodies of peripheral sensory neurones that transmit impulses from sensory receptors are situated in the posterior root ganglia. The nerve process from these cells divides into a central and a peripheral branch thus connecting the sensory receptor to the central nervous system. The central division is carried

by the posterior root to the posterolateral sulcus where it enters the spinal cord.

Peripheral nerve fibres can be classified into three main groups (A, B and C), according to their diameter, the degree of myelinization and the rate at which they conduct impulses. Most of the sensory fibres in group A are thick, heavily myelinated, transmit impulses rapidly and carry touch, pressure, proprioception and vibration. Other lightly myelinated and smaller A fibres (γ) carry touch, pressure and some pain and temperature. Group B fibres are small, lightly myelinated, preganglionic autonomic fibres. Group C fibres are small, unmyelinated, transmit slowly and carry pain and temperature.

Fibres carrying light touch synapse in the posterior horn with second order neurones. These travel to the opposite side of the cord in the anterior white commissure after which they turn upward to travel in the anterior spinothalamic tract. These second order neurones terminate in the ventral posterolateral nucleus of the thalamus where third order neurones originate and carry sensory impulses in the thalamo-cortical fibres to the sensory cortex.

Fibres carrying tactile discrimination do not cross the spinal cord after entering it but turn directly upwards without synapsing to terminate in the nuclei gracilis and cuneatus in the lower medulla. Second order

neurones from these nuclei cross to the opposite side of the medulla and sweep up through the brain stem to the ventral posterolateral nucleus of the thalamus in a broad band of fibres called the medial lemniscus. Third order neurones in common with those carrying light touch are conveyed to the sensory cortex by the thalamo-cortical fibres which occupy the posterior limb of the internal capsule.

This is the generally accepted specific theory for the transmission of sensory impulses, i.e. that there is a fixed transmission system from the somatic receptor to the appropriate area in the brain. It has also been generally accepted that as far as pain is concerned, the intensity is proportional to the extent of the tissue damage though the 'pattern' theory of pain suggests that the nerve impulse pattern subserving pain is caused by excessive stimulation of non-specific receptors.

On the basis of their work into pain and its variable relationship to the stimulus which provoked it, Melzack and Wall (1965) proposed that neither theory was satisfactory. Their view was that the brain received information about pain by way of a 'gate controlled' system which was influenced not only by the fibres carrying pain but also by other afferent stimuli and descending controls from the brain. This modulating effect took place in the interneurones of the dorsal horn of the

spinal cord before the impulse was transmitted to the higher centres and further modulation took place at successive synapses during transmission.

There are two recognised forms of pain. One is a sharp pricking rapidly transmitted pain with little emotional counterpart and the other is a slower burning type of pain, badly localised and often associated with an emotional element. According to Melzack and Wall, the lightly myelinated A fibres (δ) and the unmyelinated C fibres respond only to pain while other thicker afferents transmit pain impulses only when the stimuli have reached a certain intensity. They proposed that the A (δ) and C fibres open the 'gate' by exciting the interneuronal cells in the dorsal horn of the spinal cord and tend to keep it open by tonic impulses. The large fibre inputs, often carrying innocuous information, inhibit the cells in the dorsal horn and therefore tend to close the 'gate'.

In a recent examination and restatement of the gate control theory of pain, Wall (1978) found that various workers had confirmed that this in fact took place. There was also support for an essential corollary of the theory that stimulation of the large diameter afferents should raise the threshold for detecting pain in the area served by that nerve. It has long been accepted that rubbing or scratching in an area where there is pain brings relief

and Wall found support for this hypothesis in the clinical field where the use of counter irritation by various methods was successful in the treatment of patients with chronic pain.

Wall also found experimental evidence to support the third aspect of the gate control theory that the cord cells receiving signals from the peripheral nerves were under control of the higher centres. Melzack and Taenzer (1977) in a review of clinical work on the relief of pain also came to the conclusion that the only reasonable explanation, apart from the psychological modulation of pain, was that there were powerful inhibitory areas in the brain stem which he considered to be a 'central biasing system'. These areas receive input from the rest of the body and in turn project it to all levels of the cord and brain. Further, these areas appear to be activated by the small A (δ) and C fibres, so that intense stimulation which activates these fibres and tend to open the 'gate' in the spinal cord can also close it by the central biasing system. Melzack considered this concept vital in the approach to the treatment of pain.

It is clear that there is support for the 'gate control' theory of pain though how the control is achieved is still obscure. Obviously the large diameter afferents have a large part to play in this control and when more is known about the mechanism of the 'gate',

then the transmission of discriminative sensation might not be as simple as the specific theory suggests.

The Parietal Lobes

In contrast to the sensory pathways in the cord, sensory processes in the brain are less well understood. The parietal lobes containing the primary sensory cortex and the sensory association areas, extend posteriorly from the central sulcus to the parieto-occipital sulcus and are separated from the temporal lobes by the lateral fissure. The primary sensory cortex is situated in the post central gyrus and as in the motor cortex, the body is represented somatotopically but upside down with the head ventro-laterally and the leg dorso-medially. The primary sensory cortex receives information directly from third order neurones whereas the association area receives its information indirectly by means of association fibres.

The contribution of each part of the parietal cortex to sensory discrimination has been the subject of disagreement. Head and Holmes (1911) and Evans (1935) firmly placed the responsibility for sensory discrimination in the parietal lobes with Head (1920) later observing that the more anterior the lesion the more severe the sensory deficit. Semmes et al (1960) suggested that there was an asymmetry of function between the two hemispheres and

also that a larger area of cortex was involved in sensory discrimination in the right cerebrum compared to the left.

Two more recent investigations have clarified the picture however. Corkin et al (1970) studied 127 patients undergoing surgery for the relief of focal epilepsy and were able to examine the effects on somato-sensory discrimination of lesions in the parietal lobes as compared with other areas of the brain. Of those with lesions in the parietal lobes, a further comparison could be made between lesions limited to the post central gyrus and to the posterior parietal lobes. The results showed clearly that the area of the brain responsible for somatosensory discrimination is the posterior central gyrus and its underlying white matter. Lesions in this area produced a deep and persistent sensory loss whereas lesions in the posterior parietal lobes were associated with slight and transitory defects. No significant loss was produced by damage to other parts of the brain.

These conclusions were supported by Roland (1976), who studied discriminative sensation in the hand in a group of 93 patients who had a confirmed circumscribed lesion in the brain with no complicating factors. By a series of tests for discrimination of size and shape, he demonstrated that direct damage to the anterior part of the middle third of the post central gyrus or undercutting

of its associated white matter, resulted in severe sensory loss in the hand. Minor losses only were seen with lesions which spared the middle third of the post central gyrus.

Neither of these investigations supported the evidence of Semmes, that a larger area of the right hemisphere was involved compared to the left. Neither did they find evidence to support the view that there was asymmetry of function of the hemispheres.

Clearly, the correlation and interpretation of sensory information with its consequent comprehension occurs in the parietal cortex and its integrity is essential for the ability to recognise familiar objects by handling them. To be able to function however, it is itself dependent on adequate sensory input. After a stroke when the internal capsule may be damaged, the individual sensory modalities may be lost. This means that even if the parietal cortex remains unscathed after a cerebrovascular accident it may be unable to formulate the sensory stimuli it receives into recognisable images and to comprehend their meaning.

Blood Supply

The blood supply of the parietal lobes is derived from two sources:

1. The middle cerebral artery which supplies the lateral

surface of the parietal lobes and also the internal capsule by means of the lenticulo-striate branches.

2. The anterior cerebral artery which supplies the medial aspect of the parietal lobes together with a narrow strip along the superior edge.

This blood supply seems straightforward, but in the elderly there is frequently a confused clinical picture and vascular syndromes can be difficult to identify. This is due to an efficient collateral system which maintains blood supply in the event of a cerebral artery becoming obstructed, so that circulation through the normal vessel of supply can become reduced without consequent brain damage. It has been shown for instance, that occlusion of one of the carotid arteries may cause no neurological impairment. Fisher (1954) in a study to correlate clinical data with pathological findings showed conclusively that total blockage of one carotid artery can exist without symptoms and also without any demonstrable effect on the brain. It follows therefore, that a situation can arise where the brain is dependent upon collateral vessels which, if occluded, may cause focal lesions far removed from their normal area of distribution.

Underlying Pathology

Arterial narrowing due to atheroma and a disturbance of circulatory dynamics due to hypotension or dehydration

are together responsible for the majority of strokes in the elderly.

Brain damage after a stroke is usually due to ischaemic infarction after occlusion of a cerebral artery and in some cases haemorrhage from a ruptured vessel is responsible. The pathology of stroke is well documented elsewhere and it was not possible in this study to investigate the underlying lesion, (page 21).

In the group of patients studied in this investigation, cerebral infarction due to thrombosis or embolus would appear to be the underlying lesion in the majority of cases.

CHAPTER 3

PRELIMINARY INVESTIGATION

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Five months were spent prior to the start of this study in attempting to discover the most practical combination of tests for detecting discriminative sensory loss, what form they should take and the particular difficulties which were likely to arise. This was an experimental exercise the aim of which was to get the feel of the problems involved in this type of research. There are no results because the number and form of the tests changed radically and often throughout this preliminary period. The conclusions are reflected in Chapters 4 and 5 but the following are some of them.

During these five months, all patients admitted to the Royal Victoria Stroke Unit as part of the Edinburgh Stroke Rehabilitation Study (Garraway et al, in press) were routinely tested for loss of discriminative sensation. Though it appeared in the beginning that there would be enough patients, only 4 had a loss of discriminative sensation and were suitable for testing. The criteria for inclusion into this study became clear and it was increasingly obvious that for the results to be meaningful, the patient must be able to comprehend the tests.

It was obvious however, that in the 4 patients tested, the sensory disorder contributed to their difficulties and also to the length of time required for rehabilitation.

It was also shown that discriminative sensory loss could recover which made the intended project worthwhile.

Nevertheless, the preliminary investigation did raise the question as to the number of suitable patients being too few. An attempt was made to include other stroke patients who were part of the control group of the Edinburgh Stroke Rehabilitation Study who had been admitted to other hospitals. This exercise was eventually abandoned because of difficulty in achieving optimum testing conditions.

After the preliminary phases it became clear to the examiner that ambitious and complicated sensory testing had no place in the assessment of the elderly stroke patient. The simpler the tests and alternatives offered, the more significant and reliable the answers were likely to be. Because there was no way to check the patients' answers if they were less than completely correct, attempting to measure varying levels of partial return of most of the individual sensory modalities was impossible. What mattered was whether the type of sensation tested was present or not.

The preliminary investigation showed unequivocally that for sensory testing to be of significance, the tests used must be comprehensible to the average elderly stroke patient who must be fully conscious, co-operative and have adequate concentration. The selection of tests and

of stroke patients was strongly influenced by the experience gained during this preliminary exercise.

CHAPTER 4

PATIENTS

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All patients studied were drawn from the Edinburgh Stroke Rehabilitation Study. These patients all over 60 years of age were admitted to hospital having been seen at home shortly after the onset of the stroke by a member of the stroke team who assessed their eligibility to enter into the study. This provided a unique opportunity to study a group of patients from the earliest days of their illness.

For the purpose of the Edinburgh Stroke Rehabilitation Study a stroke was defined as the sudden onset of a focal neurological deficit lasting over twenty-four hours due to a presumed local disturbance in the blood supply to the brain, (W.H.O., 1971). Sudden can mean a time interval ranging from a few seconds to several days and as admission to hospital was sometimes well within twenty-four hours of the onset of the stroke, a small number of patients eventually proved to have had a transient ischaemic attack.

The diagnosis of the stroke in the home was made purely on the history and the clinical evidence of a focal neurological deficit, and the only further specific investigation performed on the patients admitted to the Royal Victoria Stroke Unit was a routine skull x-ray. Further investigations such as the radio-isotope scan,

angiography or the computerized axial tomographic brain scan (CAT scan), were only employed in those patients whose clinical progress gave rise to doubt about the original diagnosis. Though the CAT scan in particular would have been the ideal non-invasive procedure to confirm the diagnosis (Isherwood and Occleshaw, 1976), its workload at the time of the Edinburgh Stroke Rehabilitation Study precluded its use for routine screening and it was difficult then to visualise a time when it might be used for epidemiological purposes.

The diagnosis and investigation of stroke has always aroused argument and the British Medical Journal (1978) in a leading article, pointed out the importance of the details of the onset and evolution of the stroke. The authors supported Weisburg and Nice (1977), in their view that if the evolution of the stroke was either truly stepwise or was complete in twelve hours, it was reasonable to accept the clinical diagnosis of a stroke but if the evolution progressed for between twelve to seventy-two hours, then a CAT scan should be done to exclude non-vascular causes. This opinion however, was tempered with the advice that caution should be used in the aged, the hypertensive and the diabetic where investigation might lead to treatment which would bring no benefit.

This view was refuted by Twomey (1978) who, in a study of brain tumours in the elderly, reviewed all

admissions to a geriatric unit over a period of seven years to see what differences there were in presentation between neoplasm and stroke. Of the 1,009 patients diagnosed as having a stroke on the basis of the definition, 'an acute cerebral disturbance due to presumed vascular origin and lasting over twenty-four hours' (Royal College of Physicians, 1974), only 0.4% were subsequently found to have an intra-cranial neoplasm. His contention was that the correct diagnosis was always suggested by the history.

There was no attempt in the patients admitted to the Edinburgh Stroke Rehabilitation Study to define the type and site of the lesion. Marquardsen (1969) found that a safe distinction between cerebral haemorrhage and cerebral infarction could never be made on clinical grounds alone and in his series had to ignore this aspect due to diagnostic difficulties. He pointed out however, that eventual outcome depended not so much on the type of brain lesion but on the extent of the cerebral damage.

In the past it has been difficult to estimate the relative incidence of the types of cerebrovascular accident even in those who died, due to inaccuracies in death certification (Heasman and Lipworth, 1966), and to the low autopsy rate of such patients (Registrar General, 1977). A more recent study from the Mayo

Clinic (Matsumoto et al, 1973), which used clear criteria for the various diagnostic categories of stroke backed up by a high autopsy rate (over 50%) showed that the incidence of the types of strokes was as follows:

Cerebral Infarction (including Embolic Infarction)	79%
Intra-Cerebral Haemorrhage	10%
Subarachnoid Haemorrhage	6%
Cause Unknown	5%

It is therefore reasonable to assume that the majority of patients admitted to the Royal Victoria Stroke Unit as part of the Edinburgh Stroke Rehabilitation Study would have suffered from a cerebral infarction, with the remainder being due to cerebral haemorrhage, subarachnoid haemorrhage or cerebral tumour.

Because of the criteria for eligibility for entry to the Edinburgh Stroke Rehabilitation Study, all patients diagnosed as having suffered a stroke and admitted to the Royal Victoria Stroke Unit, had a demonstrable hemiparesis, were conscious and had been independent in self-care pre-stroke. The majority of these patients had a good prognosis for survival (Marquardsen, 1969), but required a prolonged period of rehabilitation which made possible the study of sensory loss and its recovery.

Certain conditions are essential for the examination of sensory deficit, namely:

1. The patient must be conscious.
2. There must be no communication problems.
3. The patient's state of physical and mental health must be such that the tests involved are tolerated and possible. In particular, reasonable mental function is essential for performing the tests because the results depend wholly on the patient's co-operation and the reliability of his answers. Mental function can be difficult to assess in the first two or three weeks after a stroke. The modified Isaac Walkey (1964) mental impairment measurement as used in the Edinburgh Stroke Rehabilitation Study was used as a guide to intellectual function but a low score initially did not exclude the patient as it could subsequently improve. The Isaac Walkey test discriminates at a very low level of performance between normal and abnormal but as the important factor required for this investigation was an unclouded consciousness, the level of performance for success in the Isaac Walkey test was perfectly adequate. A persistently low score two to three weeks from the onset of the stroke usually indicated severe brain damage and the patient was obviously unsuitable for sensory testing.

4. The patient had to prove his reliability and comprehension by completing seven out of the ten tests (page 35) successfully on the unaffected or ipsilateral side. If he performed them correctly then this was an adequate indication that the loss on the affected side was significant, that the patient understood the procedure, that there was no aphasia present and testing was feasible.

All patients admitted to the Royal Victoria Stroke Unit as part of the Edinburgh Stroke Rehabilitation Study who satisfied the above conditions were routinely tested for sensory loss.

Control Group

The tests were carried out on a random sample of a population of non-demented, non-stroke individuals over the age of 60. This sample was drawn from the list of a local general practitioner (Methodology and Results, page 61).

CHAPTER 5

METHOD

METHOD

Preliminary Assessment

It was essential to confirm that the patient was in a fit state to be tested. It was found preferable to do this at a time of day when he was alert, willing to co-operate and understood what was required of him. He had to be warm, comfortable, and not worried that he was missing anything vital such as meals, visitors, etc. A certain amount of privacy was needed to allow concentration. If conditions were not right then sensory testing was abandoned for that day.

Procedure

The patient was sat up in bed or in his chair in such a position that both arms could be comfortably supported in front of him by a table or a couple of pillows.

To eliminate the necessity of using a blindfold, a screen was devised. This consisted of a wooden box out of which the top and one side had been removed and two holes large enough to go over the patient's arms cut out of the bottom edge. The screen was balanced on the table or pillows in front of the patient over his forearms. This enabled the examiner to work unseen on the patient's hands while still able to see the patient and watch his reactions over the top of the box.

Frequency of Testing

The first examination was carried out as soon as possible after admission provided the patient fulfilled the criteria for suitability for sensory testing. Thereafter, the examination was repeated at weekly intervals until discharge from hospital to home, long-term accommodation, or the patient's further stroke or death. The follow-up was then attempted on the same basis but at monthly intervals until one year had elapsed from the onset of the stroke, or as in the case of two patients, until a further stroke intervened.

In the first year of this investigation some of the patients were followed up for the year whether their sensory loss had apparently returned to normal or not. This was in order to evaluate the results to find a reliable and objective method of determining when a particular modality had returned to normal. Once this had been done, the only patients tested after discharge in the remaining months of the study were those with a persistent sensory deficit.

The tests were all repeated on the unaffected side on the first occasion of testing if the patient could tolerate it, but if not on the second. The seven tests (page 35) used to prove the patient's reliability were repeated at varying intervals as a check and always if there was any doubt about the patient's comprehension.

If this proved to be suspect, then testing was abandoned for that week. Two point discrimination was routinely done on each occasion on the unaffected hand. Due to the age of the patients, there were complications during their stay in hospital which interrupted the weekly examinations. The same was true once the patient went home with the added problem of prolonged absences from home while on holiday or staying with relatives. Every attempt was made to keep in contact with the patient so that those who had persistent sensory loss were seen at approximately monthly intervals.

Particular Problems encountered in this Study

The difficulties in examining sensory loss in a patient who has had cerebral damage have been known for many years. Head and Holmes (1911) in their attempt to relate site of the cerebral lesion with the sensory deficit laid the foundations of accurate and measured sensory testing. Critchley (1953) explored the particular difficulties in examining the patient with parietal lobe damage and Allison (1962) brought a fresh approach to the testing of the brain-damaged patient. Isaacs (1971) in particular showed the value of simple toy tests in assessing perceptual and cognitive deficits in elderly stroke patients.

With this knowledge and the experience of the preli-

minary investigation, the tests were kept as simple as possible bearing in mind also that the patient's tolerance can be limited in the early weeks after a stroke.

The questions were framed in such a way that the patient had to give a definite answer so that these were as reliable as possible. The majority of patients were very anxious to please and every effort had to be made not to suggest responses. The two alternative forced choice technique was used in the tests for size, weight and texture discrimination.

On each occasion of testing the patient was encouraged and reassured. Though in practice it had not proved to be a problem, in the stereognosis test the patient was told that the objects were not necessarily the same each week, so as to guard against his remembering them after feeling them in the unaffected hand.

During the preliminary investigation, difficulty arose over the appropriate part of the hand to be used for two point discrimination and weight discrimination. Theoretically, the flexor surfaces of the fingers distal to the D.I.P. joints should be the area tested for two point discrimination, but in stroke the loss can be so great that the measurement has to be taken down the longitudinal length of the finger. To supinate the hand, extend the fingers and keep them extended, to ensure that the points of the dividers touched the skin simultaneously

and with equal pressure proved a problem in the presence of any spasticity of the fingers, hand or elbow and especially when there was a painful shoulder. It became impossible to test the patients in a uniform way so that testing was finally done on the dorsal aspect of the hand.

Similarly the weight of an object is normally assessed in the supinated hand and the appropriate sensory information is transmitted from deep pressure receptors and the stretch receptors in the tendons. In the weight discrimination test the same problems arose in attempting to place the weights in the supinated hand and once again the weights were tested on the dorsum of the supported hand.

There were also problems in testing for light touch. It was hoped to include a test for this modality as it seemed logical to assume that light touch would have to be present before other tactile sensations could be appreciated. Other workers have attempted to develop a sensitive objective method for evaluating the modality (Sekuler et al, 1973). However, it became clear that in testing the elderly patient who has had a stroke, the test had to be kept simple and short. Also the stimulus had to be stronger than that provided by a hair or a wisp of wool in order for the answers to be reliable. Therefore, instead of simply touching the skin, the back of

the patient's hand was gently stroked with a small brush. This meant that instead of 'light touch', the test was for the ability to appreciate 'tickle'.

In the other tests, the objects could be manipulated with the arm and hand in the most comfortable position. The problem of the painful frozen hemiplegic shoulder in the rehabilitation of the patient who has had a stroke has been recognised for many years (Peszczynski, 1961; Moskowitz, 1969), and it was shown clearly in the preliminary investigation that pain from such a shoulder could be so severe that testing had to be abandoned for the day if an injudicious move was made.

No attempt was made to assess the voluntary return of power to the hand apart from determining whether the hand was flaccid or not.

Additional Data

In addition to the results from sensory testing, the following information was collected about the patients admitted to the Royal Victoria Stroke Unit during the study period:

1. Age and sex;
2. Whether the patient was right or left-handed;
3. Side of stroke;
4. Number of hours which had elapsed between the onset of the stroke and the patient being seen at home by

the doctor from the stroke team and entered into the Edinburgh Stroke Rehabilitation Study;

5. Number of days between admission to hospital and first sensory examination;

6. Placement of surviving patients at discharge from the admission ward - either to home or long-term accommodation;

7. Length of stay in hospital recorded in days. It was obvious that some patients were in hospital long after they had reached their maximum level of function because of social reasons or shortage of long-term accommodation. The cut-off point used in the Edinburgh Stroke Rehabilitation Study was therefore used and all patients who were in hospital for longer than sixteen weeks were credited with a stay of one hundred and twelve days. Six patients were in this category. Two remained in hospital for social reasons, 2 were awaiting long-term beds and 2 had developed a further illness which made it necessary to postpone discharge;

8. Functional outcome: The assessment of the functional outcome of rehabilitation in each patient was an integral part of the Edinburgh Stroke Rehabilitation Study and was carried out by the Research Occupational Therapist of the study team in a purpose-built unit for assessing Activities of Daily Living (Smith et al,

1977). A set of indices for Activities of Daily Living were developed based on the Rankin Disability Classification (1957). Each patient was assessed just before discharge from hospital and those who were going to be in longer than sixteen weeks were assessed on the one hundred and twelth day (approximately). The Rankin disability grade assigned to each patient on discharge from hospital was the one used in this study. Patients with persistent sensory loss at discharge who were followed up for a year were reassessed by the investigator at one year on the basis of their performance at their place of residence which was either their own home or long-term accommodation.

The Rankin disability classification is detailed elsewhere, but in view of the relatively small number of patients, the five grades were categorised into three as follows, for the purpose of this study:

Rankin I) Independent in walking and independent in
Rankin II) self-care.

Rankin III Independent in walking but needs some help in A.D.L.

Rankin IV) Confined to wheelchair or bed.
Rankin V)

CHAPTER 6

DESCRIPTION OF TESTS

DESCRIPTION OF TESTS

Summary of Tests

1. The ability to appreciate tickle - simple tactile sensation.
2. The ability to discriminate between Texture of materials.
3. The ability to discriminate between Sizes of objects.
4. The ability to discriminate between Weights of objects.
5. The ability to discriminate between geometric Shapes.

(2, 3, 4, 5) — Discriminative Sensation

6. The ability to identify common objects.
7. Two point discrimination.

(6, 7) — Highly Discriminative Sensation

8. The thumb finding test - proprioception.
9. Assessment of the flaccidity of the hand.

The tests used in the unaffected hand to establish a base-line and the patient's reliability were 1, 2, 3, 4, 5, 6, and 9.

Two point discrimination was tested on the unaffected or ipsilateral hand on each occasion.

The tests for Shape and Form were combined and are referred to as a single test for 'Shape' from now on.

THE TESTS

1. Appreciation of Tickle

A small soft brush was used. The back of the patient's hand was stroked with the brush at three irregular intervals, e.g. 2, 9, 4 seconds. The patient was asked to say 'yes' on each occasion he felt the touch of the brush.

A record was made of the number of times the patient was correct.

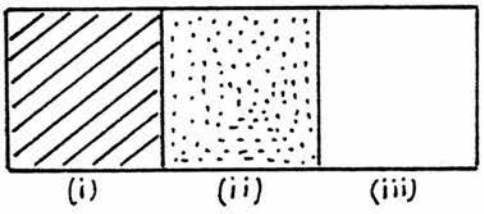
2. Ability to Discriminate between Textures

Three different materials were selected to give a simple range from rough to smooth. Half a ceramic tile was used and a square from each of the other two materials was stuck on to it as illustrated in the diagram.

(i) Rough sandpaper,

(ii) Towelling,

(iii) Tile.



The affected hand was held so that one of the textures could be gently rubbed three or four times against the tips of the second and third fingers. Immediately after, this was repeated with the next texture and the patient was asked which was the rougher. The surfaces were tested in pairs and also in order of increasing difficulty (i.e. a less dramatic difference between textures).

(i) Sandpaper with tile,

(ii) Sandpaper with towelling,

(iii) Towelling with tile.

A record was made of the number of correct replies.

3. Ability to Discriminate between Sizes

Three plastic toy tubs, identical in shape but of different sizes were used. Again they were tested in pairs, one tub being put in the affected hand followed shortly by a second. In the flaccid hand, the tub was manipulated in such a way that the patient had every opportunity to assess its size. The patient was asked on each occasion which was the larger. The pairs were tested in the same order on each occasion:

(i) Large with smallest,

(ii) Large with medium,

(iii) Medium with smallest.

A record was made of the number of correct replies.

4. Ability to Discriminate between Weights

Three different weights were used - 100g, 50g and 10g. Each weight was put into an identical box which was padded so that the weight could not move about.

The same procedure was used as in the previous test with the weights being used in pairs and the patient being asked on each occasion which weight was the heavier. The weights were dropped from the height of one inch onto the dorsum of the hand and care had to be taken that the hand

and forearm were adequately supported. Weight pairs were used in the same order on each occasion:

(i) Heavy with light,

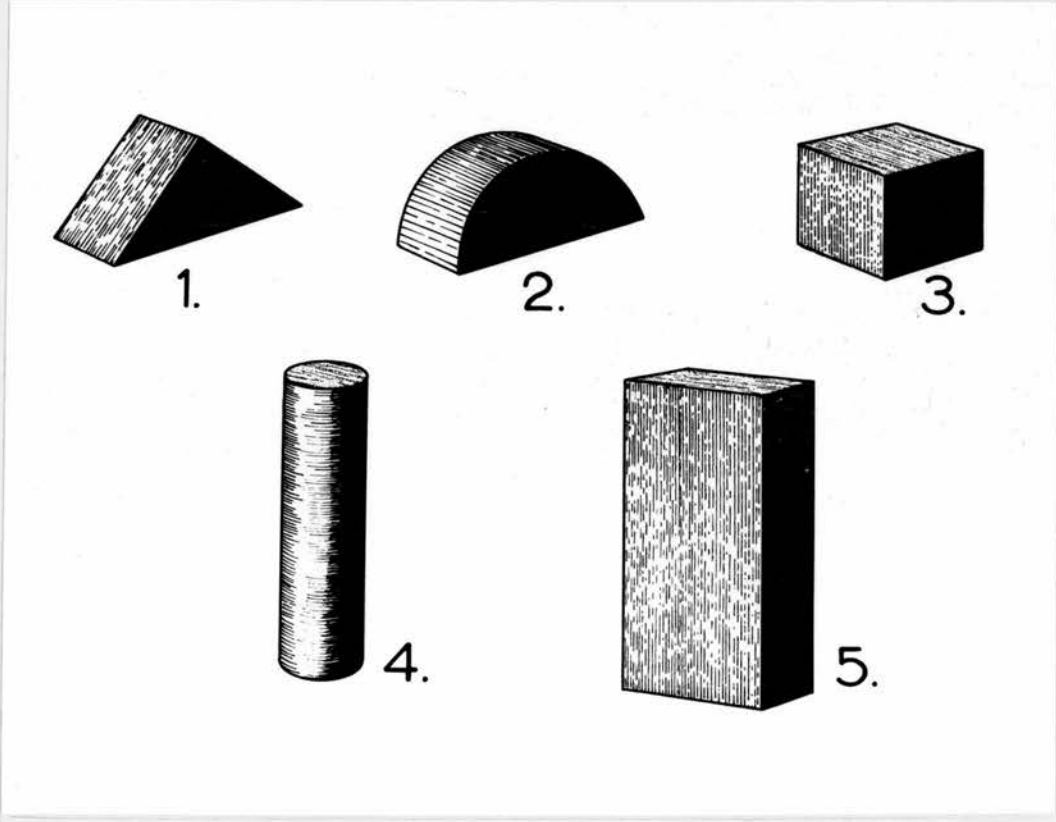
(ii) Heavy with medium,

(iii) Medium with light.

A record was made of the number of correct replies.

5. The Ability to Discriminate between Geometric Shapes

Five solid wooden geometric bricks of different shapes were used.



They were similar in texture but not exactly of equivalent volume. A board with a diagrammatic picture of each of the bricks on it was placed in front of the patient.

Each brick was manipulated in the affected hand in turn and the patient was asked to identify it on the board. The brick was also pressed into the palm of the hand so that the patient had the opportunity to feel its outline. The patient was told that the bricks would be presented in any order and that any one brick might be presented twice.

The patient's sight had to be satisfactory for this test and care had to be taken that the board was within his field of vision.

A record was made of the number of correct replies.

6. Stereognosis - the Ability to Identify Common Objects without Looking

Six common objects familiar to both sexes and to patients from different walks of life, were selected. They were:

(i) Orange,
(ii) Brush,
(iii) Handkerchief or piece of soft material,
(iv) Rope,
(v) Key,
(vi) 10 pence Coin.

Each object was placed in the affected hand and again if there was no return of voluntary movement, the object was manipulated in the hand while the patient was asked what it was. The only object to prove difficult in a

flaccid hand was the coin, because it was so small, but as it was highly suitable in other ways for this test it was included.

Objects correctly identified and those not identified were recorded.

7. Two Point Discrimination

The points of a divider were simultaneously applied to the back of the patient's hand in the horizontal axis of the body. The initial distance between the points was 25 mm. The distance was increased by 2 mm at a time until the patient was able to appreciate each point, separately. The procedure was then reversed by decreasing the distance between the points by 2 mm at a time until the patient could only feel one point. The distance between the points was then gradually increased again until the patient once more felt two points.

This distance was recorded for the affected and unaffected hand.

8. Proprioception

Unaffected side - the patient was asked to touch his/her nose with the forefinger of the unaffected hand. This was then repeated with the eyes closed, and if the patient was able to touch any part of the nose or touched the face no more than $\frac{1}{2}$" from the nose and then found the nose, proprioception was considered normal in the unaffected arm.

Affected side - the examiner then lifted the affected arm so that the hand was on a level with the patient's eyes. The patient was asked to grasp the thumb of the affected hand with the unaffected hand and then to release it. The examiner then covered the patient's eyes and raised the affected hand to well above the patient's head. The patient was asked to grasp his thumb as before.

Scoring

0 - The patient was unable to find his thumb or the affected arm.

1 - The patient found the affected arm and this led him to his thumb.

2 - The patient aimed in the right direction but missed the thumb by no more than three inches and could locate it within five seconds.

3 - The patient was able to accurately locate the affected thumb.

9. Assessment of Grasp of Affected Hand

The cylindrical brick from the shape discrimination test was used. It was placed in the patient's hand and the patient instructed to grasp it firmly. The arm was then raised to see if the brick fell out of the hand due to gravity or not. A record was made of the result as follows: 0 = Flaccid; + = Enough power and/or spasticity to retain the brick.

CHAPTER 7

SCORING METHOD

SCORING METHOD

Assessment of Return to Normal Function

One of the problems encountered in this investigation was that of obtaining objective and reliable identification of a return to normal of sensory modalities. This is clearly of fundamental importance to the aims of this investigation. The result of a single test cannot be relied upon because it is possible for the patient to achieve the maximum score purely by chance.

Tests for Texture, Size, Weight and Tickle

The answers given by patients to the two alternative forced choice tests for the appreciation of texture, size and weight were analysed in order to discover the smallest number of successive maximum scores achieved by the patient which would reliably indicate a return to normality. The patient had three questions to answer in each test and the chance of his achieving the maximum score in any one test with no return of discriminative sensation and therefore purely by chance, were as follows:

1. On one occasion - 1 in 8.
2. On two consecutive occasions - 1 in 64.
3. On three consecutive occasions - 1 in 512.

From these figures it would seem reasonable to accept two consecutive maximum scores as an indication that a

particular modality had returned to normal; but obviously three consecutive scores would be even more convincing.

To examine this further, the data collected before discharge from hospital were examined to determine the following:

1. If two successive maximum scores were followed by a third maximum score.
2. If three successive maximum scores were followed by a fourth maximum score.

Data collected before discharge from hospital were used because this was when testing was done under optimum conditions and results were therefore more reliable than after discharge. The results for tickle were looked at in the same way.

In common with other neurological tests requiring a high degree of patient co-operation, tests for sensation are critically dependent upon the patient's ability to concentrate and to remain interested in the procedure. Even in favourable circumstances, fatigue or mild intercurrent illness was enough to distract the patient and to produce an abnormal result after a succession of maximum scores. To show that such abnormal results were temporary and not due to any permanent neurological change, the results of the suceeding tests were examined to find out if maximum scores were regained. This was possible as all patients in the group were routinely tested on a

weekly basis until discharge even after maximum scores had been achieved. The results of this exercise were as follows (Table 2, page 51):

1. After three consecutive maximum scores

   In seventy such tests only seven were not followed by a fourth consecutive maximum score. All seven subsequently regained the maximum score before discharge.

2. After two consecutive maximum scores

   In seventy-five such tests, only six were not followed by a third consecutive maximum score. Of these six, one subsequently regained the maximum score before discharge but five did not.

It would seem reasonable to infer from these results that three consecutive maximum scores indicate a return to normal.

Tests for Shape and Form

The identification of the bricks in the test for shape and form presented a different problem in that the chances of a patient with no return of discriminative sensation achieving the maximum score on a single occasion were very low ($P = 0.0003$). It could therefore be assumed that a single score of 5 would indicate recovery. It was also evident that when a patient had achieved a score of 3 or more on two consecutive occasions, this score was

usually maintained and/or improved upon.

To verify this, the results of the tests for shape and form were examined to determine:

1. If a maximum score of 5 was followed by a second maximum score.
2. If two consecutive maximum scores were followed by a third maximum score.
3. If scores of 3 followed by another 3, 4 or 5 were followed by a score of 3, 4 or 5.

The results of this investigation were as follows (Table 3, page 51):

1. <u>After a single maximum score of 5</u>

   In fifteen such tests, seven were not followed by a second consecutive maximum score. Of these seven, six regained the maximum score before discharge and one did not.

2. <u>After two consecutive scores</u>

   In twelve such tests, two were not followed by a third consecutive maximum score. Of these two, one regained the maximum score before discharge and one did not.

3. <u>After a score of 3 followed by a 3, 4 or 5</u>

   In sixteen such tests, two were not followed by another 3, 4 or 5. Both regained scores of 3, 4 or 5 before discharge.

There was very little difference between the first two groups and therefore, the first maximum score achieved by the patient seemed a reliable indication that his modality had essentially returned to normal. In addition, the results in the third group confirmed that a score of 3 followed by a 3, 4 or 5 was, in the longer term, always improved upon or maintained and was therefore an indication of a partial return (indicated by $\frac{1}{2}$).

Proprioception

The thumb finding test is reliable, objective and can be measured. Therefore, a single maximum score was taken to indicate a return to normal function and lower scores could also be taken into consideration. In particular, the highest score achieved during the whole of the hospital stay was taken to indicate the level of recovery of proprioception.

Stereognosis

Stereognosis is the result of a summation of all the modalities together with a higher cortical component. In this test the patient either identifies the objects or he does not. Although a maximum score indicates a return to normal function the lowest scores are also significant. As with proprioception, the highest score achieved during the hospital stay was the value used to

assess recovery.

Two Point Discrimination

The value for two point discrimination varies widely in any particular patient and some measure had to be determined to identify a return to 'normal'. On the basis of general clinical experience and a small pilot study on patients with no neurological deficit and in the same age range, it was decided that 40 mm was a reasonable value for the upper limit of normal on the back of the hand.

This value was in fact confirmed by the results from the random sample (page 65).

The patient's results could then be scored as follows:

TABLE 1

DIVIDER DISTANCE	SCORE	INTERPRETATION
Under 40 mm	3	Patient has normal discriminative sensation
Over 40 mm but under full width of hand	2	Patient has regained a degree of discriminative sensation
Patient feels one point only at full width of hand	1	Loss of functional discriminative sensation
No sensation	0	Total sensory loss

It was evident that a single score of 3 did not indicate a return to normal function and therefore the data for the unaffected hand as well as the affected were analysed as follows to determine:

1. If two maximum scores were followed by a third maximum score.
2. If three maximum scores were followed by a fourth such score.
3. If a score of 2 followed by a 3, or vice versa, was followed by another 2 or 3.

The results of this exercise were as follows (Table 4, page 52):

1. After three successive maximum scores

   In the unaffected hand there were eighteen such tests and five of these were not followed by a fourth maximum score. Of these five, four regained the maximum score before discharge and one did not.

   In the affected hand there were six such tests and all were followed by a fourth maximum score.

2. After two successive maximum scores

   In the unaffected hand there were twenty-one such tests and three of these were not followed by a third maximum score. Of these three, two regained the maximum score and one did not.

   In the affected hand there were twelve such tests and seven of these were not followed by a third

maximum score. Of these seven, five regained the maximum score and two did not.

3. After a score of 2 followed by a 3 or vice versa

In the unaffected hand there were nine such tests and only one was not followed by a score of 2 or 3 and the score in this test was not maintained.

In the affected hand out of eight such tests, one was not followed by the maximum score, but a score of 2 or 3 was regained.

Comparing the first two groups, three successive maximum scores is obviously the most reliable indication of a return to normal, especially in the affected hand. The third group confirmed that a partial return of two point discrimination was indicated by the score of 2 followed by a 3, or vice versa.

To Summarize

The scores which indicate a return to normal of each type of sensation are as follows:

1. Discrimination of texture, size, weight and tickle - three consecutive maximum scores.
2. Discrimination of shape and form:

   Full return - one maximum score;

   Partial return - score of 3 followed by a 3, 4 or 5 (indicated by $\frac{1}{2}$).
3. Proprioception - a single maximum score.

4. Two point discrimination:

   Full return - three consecutive maximum scores;

   Partial return - score of 3 followed by a 2 or vice versa.

5. Stereognosis - a single maximum score.

TABLE 2

TESTS FOR DISCRIMINATION OF TEXTURE, SIZE, WEIGHT AND TICKLE

	No of Tests	Tests not followed by Maximum Score	Conclusion
After three Maximum Scores	70	7 - all regained maximum scores	Criterion Acceptable
After two Maximum Scores	75	6 - 1 regained maximum score 5 did not	Criterion Not Acceptable

TABLE 3

TESTS FOR DISCRIMINATION OF SHAPE AND SIZE

	No of Tests	Tests not followed by Maximum Score	Conclusion
After two Maximum Scores	12	2 - 1 regained maximum score 1 did not	Criterion Acceptable
After one Maximum Score	15	7 - 6 regained maximum score 1 did not	Criterion Acceptable
Tests not followed by a 3, 4 or 5			
After a Score of 3 followed by 3, 4 or 5	16	2 - 1 maintained the score 1 gained maximum scores	Criterion Acceptable

TABLE 4

TESTS FOR TWO POINT DISCRIMINATION

		No of Tests	Tests not followed by Maximum Score	Conclusion
After three Maximum Scores	Unaff	18	5 - 4 regained maximum score 1 did not	Criterion Acceptable
	Aff	6	0	
After two Maximum Scores	Unaff	21	3 - 2 regained maximum score 1 did not	Criterion Not Acceptable
	Aff	12	7 - 5 regained maximum score 2 did not	
Tests not followed by a 2 or a 3				
After a Score of 2 followed by a 3 or vice versa	Unaff	9	1 - did not regain a 2 or a 3	Criterion Acceptable
	Aff	8	1 - 1 regained score of 2 or 3	

SENSORY STATUS ON ADMISSION AND DISCHARGE

To establish a base-line with which to compare the recovery of sensation during hospital stay, sensation had to be tested at the time of admission into the stroke unit. It was thus possible to relate recovery of sensation to recovery of function, length of stay in hospital and final placement. Pre-discharge assessment of sensation was performed when the patient was ready to be returned home or to institutional care. Some patients who were tested on admission died before discharge.

On Admission

Before determining the relevant modalities of sensation on admission, the possibility had to be considered that the stroke might be in evolution when the patient was first seen and that several days would elapse before it became fully established. It followed therefore, that the first and even the second occasion of testing might fall within this period. Therefore the patient's initial sensory status was assessed over the first three occasions of testing as follows:

1. The tests for the recognition of texture, size, weight, shape and tickle were only considered to be normal after the onset of the stroke if the maximum score was achieved on all of the first

three occasions of testing. A partial loss of the ability to appreciate shape was considered to be present if the score was 3 or 4 on each of the first three occasions of testing.

2. The lowest score during any of the first three occasions of testing of proprioception, two point discrimination and stereognosis was taken to be the base-line for these modalities. As mentioned earlier, due to the nature of these tests, lower scores can be taken into consideration.

On Discharge

On discharge from the stroke unit, the results of sensory testing over the whole of the patient's stay were examined and the recovery of sensation during this period was assessed in the manner described previously. It was evident from this that the recovery of sensation had to be assessed on the basis of the tests performed over a significant period of time and that the results of testing on a single occasion before discharge were of limited value.

In a number of patients it was appropriate to repeat the tests once or twice just before discharge. Although these patients had achieved maximum scores in all the tests on one or two occasions by the time of discharge, they had not as yet attained maximum scores on the

three consecutive occasions required to demonstrate that a particular modality had returned to normal. In order to avoid having to test the patient after discharge, the tests were repeated the required number of times just before discharge to confirm that the modalities had in fact returned to normal.

The highest scores in proprioception and stereognosis achieved over the whole of the period in the stroke unit were taken to be the measure of recovery of these modalities.

Patients who had not achieved maximum scores by discharge were followed up in the post-discharge period for one year from the time of the onset of the stroke when a final assessment of recovery was made.

All the tests were repeated on each occasion. The only exceptions were 3 patients who were followed up for proprioception and two point discrimination only, the other modalities including stereognosis having returned to normal before discharge.

Two patients had a second cerebrovascular accident which altered the neurological profile and therefore their post-discharge follow-up was shorter than a year.

CHAPTER 8

OBSERVER VARIATION STUDIES

OBSERVER VARIATION IN TESTS FOR SENSORY DYSFUNCTION AFTER STROKE

In any clinical investigation it is important to demonstrate that the results of tests used to detect dysfunction can be repeated by the one observer on more than one occasion, provided what is tested remains constant. It is also of value to show that an independent examiner can repeat the tests on the same subject and obtain results similar to the main observer. The value of this exercise is to demonstrate the reproducibility of the tests when performed by a single observer or by different observers. The particular problem in observer variability in stroke assessment has been recently shown (Garraway et al, 1976).

In order to validate the reproducibility of the tests used in this investigation, 6 stroke patients with stable sensory abnormality out of a total of 31 stroke patients in the study, were selected. It proved to be difficult to find 6 patients who were physically and mentally able to cope with the requirement of this investigation, which involved being examined twice in a short period of time and by more than one examiner.

Four out of 6 patients had been discharged home, but were still attending the outpatient department for physiotherapy. The other 2 had been in hospital for nine and seven weeks respectively and were still under-

going rehabilitation. The 4 outpatients were examined in the familiar circumstances of the day hospital where the monthly testing was normally carried out and the 2 inpatients were tested in the ward.

The two independent observers were third year students, (one medical and one dental) who had no previous experience of conducting this type of examination.

The students were given a written description of the tests (Chapters 5 and 6). After reading this, a demonstration of the tests was carried out by the researcher followed by a short discussion of the relevant points before the students performed the examinations.

Testing was carried out as follows (the students are referred to as 'A' and 'B' and the research worker as 'R'):

1. Four of the 6 patients were examined in the following order:

   (i) Patient No. 1 was examined by A followed by R.

   (ii) Patient No. 2 was examined by R followed by A.

   (iii) Patient No. 3 was examined by B followed by R.

   (iv) Patient No. 4 was examined by R followed by B.

   Consequently as there were 10 tests carried out by each observer on each patient, there were 20 pairs of tests to be compared between the research worker

and each student.

Results: a. Student A and research worker - 18 agreements out of 20 pairs of tests.

b. Student B and research worker - 16 agreements out of 20 pairs of tests.

This gave a total of 34 agreements out of 40 pairs of tests.

2. These 4 patients were re-examined by R within four days and the results compared with those obtained by R on the initial testing. This again gave 40 pairs of tests.

Result: There were 35 agreements out of a total of 40 pairs of tests.

3. Patients 5 and 6 were examined by R while being observed by A and B and all three examiners recorded their scores of R's testing independently.

Result: Total agreement.

Comment

Fletcher and Oldham (1964) stated that the intrinsic accuracy of a test is the aspect most often considered by investigators to be vulnerable to variation, whereas the constancy of what is being measured and also the ability of the observer to interpret and record the results is often forgotten.

In practice, the main variable in an investigation

such as this, is the patient himself. The problem of examining him under suitable conditions has been discussed on page 27 . As far as this observer variation exercise is concerned the particular difficulties were:

1. The patient became tired during the second examination.
2. The patient was anxious to 'do well', to please the examiner and was therefore more nervous than usual. One became very tearful though apparently enjoying the occasion and the company.
3. The patient's concentration wavered during the inevitable delays caused by the students having to refer to their written instructions. The students were naturally not so adept at the procedure as was R.

Because the actual objects used for the tests were constant, the only important variable apart from the patient was the skill and the consistency of the examiner in applying the tests. It was vital that the questions were asked in the prescribed manner without any hint of suggestion and the patients given every opportunity to feel the objects and ample time to consider their answers. The instructions though simple, had to be clear and fully understood by the patient. If they were not, there would be considerable scope for error.

In view of these considerations having been carefully

applied during the performance of the tests, it is judged that the results of these tests of extra and intra observer variation indicated an acceptable level of reproducibility for the purpose of the main investigation.

CHAPTER 9

A RANDOM SAMPLE

RANDOM SAMPLE

In order to validate the tests and to establish their value in assessing sensory dysfunction after a stroke, it was essential to establish what the results would be if the range of tests were carried out on a random sample of non-demented, non-stroke patients over the age of 60 in the general population.

A two man general practice in the City of Edinburgh composed of 4,687 patients was used for this purpose. Patients were drawn from two different parts of the city, an older central area and an outlying area composed mainly of council housing. This particular practice had an 'F' or Family book which simplified the task of extracting the patients by age and sex.

The number of patients in the study was 31 and the aim was to have a random sample of at least that number, matching the study by age and sex. From previous experience it could be anticipated that some patients might not be traced or be unsuitable for testing, so a sample of double the study size was selected in the first instance (i.e. a total of 62).

A total of 793 patients over the age of 60 and under 90 years were collected from the 'F' book. There were 492 females and 301 males who were stratified by five year age intervals to give a total of twelve groups of

patients who were then listed and numbered. Using the random number table in Documenta Geigy (1970), a simple random sample was taken from each group of patients - in each case, the sample was double the number of the study in each particular age group.

The records of these 62 patients were then scrutinized to eliminate those who would be unsuitable for testing on the basis of previous stroke, existing dementia or other serious illness. If in any particular stratum of patients the sample number dropped below the study number, then further patients were randomly selected for that group.

Out of the total sample of 62, there was a loss of 21 and out of a further 10 randomly selected, 3 more were found to be unsuitable for testing. Therefore in a total of 72 patients randomly selected, 48 were found to be suitable and 24 unsuitable for testing on the basis of their medical records. The loss of 24 was accounted for as follows:

Notes not traced (patients may have gone away, died or been under current review by general practitioner)	11
Patients found to have died	4
Medical reasons other than stroke (terminal cancer, psychiatric illness, etc.)	7
Previous cerebrovascular accident	2
	24

The remaining 48 patients were all contacted by letter and invited to take part in an examination of their hands. A total of 36 were consequently seen and tested. The fall-out of 12 was due to:

4 refused to co-operate.

4 returned by G.P.O. or had "gone away".

1 died.

3 not suitable for testing. One patient had had a stroke five days previously, another was so totally deaf that testing was impossible and a third was found to be confused.

Three more patients had to be randomly selected to make up the numbers in a particular group. Of these, one had died but the other 2 were successfully visited. Therefore, a total of 38 patients were eventually visited and tested in their homes.

Procedure

A brief medical history was taken to confirm that there had in fact been no cerebrovascular incident or other neurological disease in the past. The intellectual function test as used in the Edinburgh Stroke Rehabilitation Study (the modified Isaac Walkey mental impairment test, 1964), was carried out to ensure that the patients were intellectually able to co-operate and to understand the procedure. Each hand was then tested in the manner

described in Chapters 5 and 6.

Two point discrimination was measured and an exact note of the patient's answer made in each case. The aim was to determine in the random sample of the population what was the upper limit of "normal" in order to be able to correctly assess the measurements obtained from the stroke patients. With the other tests, i.e. those for the ability to appreciate tickle, texture, size, weight and shape, proprioception, identification of common objects and the grip of the hand, the only significant score was when the patient gave the correct answer in every case.

By excluding the two point discrimination test, there were therefore 8 tests on each hand, 16 in each patient and a total of 608 in the whole random sample of 38 patients.

Results: 1. Out of the total of 608 tests there were 8 (13%) where the maximum score was not achieved.

2. The measurements for the two point discrimination test for each hand are shown in Table 5 on page 65.

TABLE 5

RANDOM SAMPLE - TWO POINT DISCRIMINATION
ON THE BACK OF THE HAND

AGE STRATA	MALE		FEMALE	
	R.H.	L.H.	R.H.	L.H.
60-64 Years	35 24	28 25	33 24	31 24
65-69 Years	35 25 32 29 29 29	35 37 33 32 36 24	15 31 25	22 33 28
70-74 Years	10 21	11 30	28 24 20 27 24 26	32 24 20 26 23 26
75-79 Years	29 34	32 35	28 27 36 39 36 34 33	25 29 35 30 29 33 37
80-84 Years	30 40	39 37	44 33 1 pt only 34	43 36 35 26
85-89 Years	39 39	40 32		

(Measured in millimetres)

Comment

The low number (1.3%) of tests where the significant score was not achieved indicates that the tests discriminate at a very low level of performance. Therefore it can be said that in a stroke patient with reasonable intellectual function who has had no previous cerebrovascular incident or neurological disease, these tests will demonstrate clearly if there has been any loss of discriminative sensation.

It would also seem reasonable to assume that 40 mm can be regarded as the upper limit of 'normal' for two point discrimination on the back of the hand.

CHAPTER 10

RESULTS

RESULTS

All patients admitted to the Royal Victoria Hospital Stroke Unit as part of the Edinburgh Stroke Rehabilitation Study over a period of twenty months were routinely tested in the manner described in Chapters 5 and 6.

After testing for stereognosis, those patients (listed in the Appendix, Tables 37, 38, 39, 40) were divided into three groups:

1. The Abnormal Group - Patients with loss of stereognosis (31 patients).
2. The Normal Group - Patients with normal stereognosis (40 patients).
3. The Untestable Group (29 patients).

The essential features of these groups are in Table 6. From now on patients with abnormal stereognosis are referred to as the STUDY GROUP.

More females than males were admitted into the Stroke Unit over the twenty months and the proportion of females in the study group was 65%.

The majority (68%) of the patients in the study group had left hemiplegia. Right hemiplegia was more common in the normal group (60%) and, as could be anticipated because of the prevalence of language disorder in right hemiplegia, in the untestable group (72%).

ABBREVIATIONS USED IN TABLES

A or Aff - Affected

F - Female

L - Left

L.T. - Long-term

M - Male

Mods - Modalities

N/K - Not Known

Pt or Pnt - Point

Pro, Prop or Proprio - Proprioception

R - Right

Sh or Sha - Shape

Si or Siz - Size

SE - Standard Error

Ster, Stere or Stereog - Stereognosis

Tx or Tex - Texture

Tic or Tkl - Tickle

U or Unaff - Unaffected

Wt or Wei - Weight

TABLE 6

	Age in Years Mean ± SE	Sex M	Sex F	Side R	Side L	Days in Hosp of Survivors Mean ± SE	OUTCOME Home	OUTCOME L.T. Care	OUTCOME Further Stroke/ Death	No of Survs	Rankin Grades of the Survs I+II	Rankin Grades of the Survs III	Rankin Grades of the Survs IV+V
ABNORMAL GROUP (31)	72.6 ±1.2	11	20	10	21	72.2 ±6.3	22	5	4	27	11	8	8
NORMAL GROUP (40)	72.9 ±0.9	17	23	24	16	38.1 ±4.3	39		1	39	34	1	4
UNTESTABLE GROUP (29)	73.3 ±1.3	15	14	21	8	67.3 ±8.1	14	5	10	19	6	7	6

TABLE 7

	Age in Years Mean ± SE	Sex M	Sex F	Side R	Side L	Days in Hosp of Survivors Mean ± SE	OUTCOME Home	OUTCOME L.T. Care	OUTCOME Further Stroke/ Death	No of Survs	Rankin Grades of the Survs I+II	Rankin Grades of the Survs III	Rankin Grades of the Survs IV+V
NORMAL A (26)	72.9 ±1.2	9	17	15	11	37.7 ±5.6	26			26	22	1	3
NORMAL B (14)	72.8 ±1.6	8	6	9	5	38.9 ±6.5	13		1	13	12		1

There was no way of knowing how many of those in the untestable group with language difficulty had discriminative sensory loss.

The patients in the study group were seen at home within nine hours (mean 8.7 ± S.E. 1.9) after the onset of the stroke. The first sensory examination was carried out within six days (mean 5.9 ± S.E. 0.5) of the onset of the stroke.

In 3 out of the 31 patients it was their second stroke, the initial episode having been over one year previously and from which they had made an excellent recovery.

The striking feature was the difference in the length of stay in hospital which clearly showed that stroke patients with sensory loss required a longer period of rehabilitation. The problems which this type of stroke produce were also shown by the placement of the patients at discharge from hospital with only 71% of the study group going home compared to 98% of the normal group (i.e. patients without loss of stereognosis). This was also reflected in the Rankin Disability Grades achieved by the two groups by discharge in that 85% of the normal group were independent in self-care (I-II) compared to the study group where 61% were independent in walking and only 36% independent in self-care.

The normal group could be subdivided as follows (Table 7):

Normal Group A: Those with entirely normal sensation, (but not necessarily two point discrimination).

Normal Group B: Like group A but with proprioceptive loss.

In the normal group B, the loss of proprioception was mild except in one case, but in all patients this had returned to normal by the end of four weeks.

In the normal group A, 6 patients had abnormal two point discrimination in the affected hand (i.e. the side of the hemiplegia). All of these patients had abnormal two point discrimination in the unaffected hand also. Three of these patients were normal in both hands by discharge but 3 were still abnormal.

In group B there were 3 patients with abnormal two point discrimination in the affected hand only. All 3 had returned to normal by discharge.

The untestable patients were not followed up apart from what is noted in Table 6. It is difficult to categorize them precisely, but the reasons for the 29 patients being untestable were broadly as follows:

19 patients - predominantly a language problem;

4 patients - predominantly confusion;

4 patients - poor conscious level;

2 patients - gross neglect of the left-hand side of space.

Using the scoring method described in Chapter 7, the results of sensory testing at certain points in time were considered. The three points in time selected for this purpose were:

1. On Admission, shortly after the onset of the illness.
2. Shortly before discharge from hospital (either to home, to long-term accommodation, or just before death or a further stroke), referred to as First Discharge.
3. At one year from the onset of the stroke if full recovery had not taken place by first discharge. This will be known as Second Discharge for the purpose of this investigation. If the patient died prior to the second discharge or suffered a further stroke, the test results preceding this event were considered.

These points in time were selected so that by establishing a base-line at the beginning of the illness, recovery by first or second discharge could be measured. Though the time of first discharge was different for every patient, it was when active inpatient rehabilitation ceased and the patient was declared to be fit for

discharge (to the patient's own home or to long-term accommodation). Therefore, this was considered to be the most appropriate time to relate sensory status to placement, length of stay in hospital and the functional status of the patients as expressed by the Rankin disability grade.

The number of sensory modalities present on admission in the study group of 31 patients were therefore determined and the patients listed as in Table 8. Seven modalities were tested which did not include stereognosis or two point discrimination in the unaffected hand. These were proprioception, two point discrimination and the ability to appreciate texture, size, shape weight and tickle.

In view of the relatively small numbers, the patients were categorized into three sensory groups rather than seven. Looking at Table 8, it may be seen that they fall into three groups:

1. Gross Loss - Patients with one or no modalities present (16 patients).
2. Moderate Loss - Patients with two, three or four modalities present (11 patients).
3. Slight Loss - Patients with five, six or seven modalities present (4 patients).

Next, each group was examined in detail to determine

its distinguishing features, i.e. age, sex, side of hemiplegia, length of stay in hospital, placement and Rankin disability grade by first discharge as well as the sensory improvement by that time.

All patients in the study group were right handed.

TABLE 8

STUDY GROUP ON ADMISSION (31 PATIENTS)

NUMBER OF MODALITIES							
GROSS LOSS		MODERATE LOSS			SLIGHT LOSS		
0	1	2	3	4	5	6	7
Nis Art Beg Wyl Cum Nor Wal Hun McM Fra Lin Glo Gib Boy Rei	Gre	Red Mas Hal	Mer Ada For Pal Whi	Rob Gil McG	Sau	All Rot	Kil
TOTAL = 16		TOTAL = 11			TOTAL = 4		

GROSS LOSS GROUP ON ADMISSION

Referring to Table 8, there are 16 patients in this group, fifteen having no sensory modalities and one having one modality. Their sensory status on first discharge can be seen in Table 9.

TABLE 9

DISCHARGE SENSORY STATUS OF PATIENTS IN THE GROSS LOSS GROUP ON ADMISSION (16 PATIENTS)

NUMBER OF MODALITIES							
GROSS LOSS		MODERATE LOSS			SLIGHT LOSS		
0	1	2	3	4	5	6	7
Art Wal Beg Nor [Rei] [Boy]	Nis Gib		Wyl Cum Hun Fra	McM [Gre]*	Lin	Glo	
TOTAL = 8		TOTAL = 6			TOTAL = 2		

[ ] = Death * Normal Stereognosis

If we refer to the movement of a patient's neurological status, due to recovery, from one sensory group to the next as a "step", the changes in the groups may be summarized in the following way:

8 patients remained with Gross Loss and made no improvement (2 died).

6 patients improved one step into Moderate Loss (one died).

2 patients improved two steps into Slight Loss.

0 patients made a total recovery.

Therefore at first discharge, the 13 surviving patients were in three sensory groups. Each of these groups were looked at separately and a summary of the essential features can be seen in Table 10.

TABLE 10

DISCHARGE SENSORY STATUS OF 13 SURVIVORS OF GROSS LOSS GROUP ON ADMISSION

Sensory Status on Discharge	Number	Age in Years Mean ± SE	Sex M	Sex F	Days in Hosp Mean ± SE	Side R	Side L
Gross	6	70.2 ±2.7	3	3	77.5 ±12.9		6
Moderate	5	71.6 ±2.3	2	3	82.0 ±14.0		5
Slight	2	80.0		2	84.5	1	1

It is interesting to note that the 2 patients who improved two steps into the slight loss group were nine to ten years older than the rest of the group.

TABLE 11

RANKIN DISABILITY GRADES OF 13 SURVIVORS OF GROSS LOSS GROUP ON ADMISSION

Sensory Status on Discharge	Number	Rankin Grades		
		I+II	III	IV+V
Gross	6	1	2	3
Moderate	5	2	1	2
Slight	2	1		1
TOTAL	13	4	3	6

More than half of the patients in this group were independent in walking (Rankin I-III) by first discharge, but if the sensory groups are related to the Rankin disability grades of the survivors at discharge the difference between the groups is minimal (Table 11). In the gross loss group, 3 out of the 6 remaining patients gained grades of I-III compared to 3 out of 5 patients of the moderate loss group.

Apart from being grouped by their sensory status, these 16 patients were examined from the point of view of their placement (Table 12).

TABLE 12

PLACEMENT OF GROSS LOSS GROUP
AT FIRST DISCHARGE (16 PATIENTS)

Placement	Number	Sex M	Sex F	Side R	Side L	Age in Years Mean ± SE	Days in Hosp Mean ± SE
Home	8	3	5	1	7	72.5 ±1.9	76.9 ±11.0
Long-Term	5	2	3		5	71.8 ±3.8	85.8 ±11.1
Death	3		3	1	2	74.7	32.3

It can be seen that half of the gross loss on admission group went home. The three deaths occurred relatively early in the course of the illness and none were due to the severity of the stroke. The cause of death in 2 patients was pulmonary embolism and in the third, myocardial infarction. The long-term patients were longer in the admission ward than those who went home which may be a reflection of the shortage of long-term hospital accommodation.

TABLE 13

RANKIN DISABILITY GRADES OF 13 SURVIVORS OF GROSS LOSS GROUP ON ADMISSION RELATED TO PLACEMENT AT FIRST DISCHARGE

Placement	Number	Rankin Grades		
		I+II	III	IV+V
Home	8	4	2	2
Long-Term	5		1	4
TOTAL	13	4	3	6

As might be expected, when placement is related to the Rankin disability grades on first discharge of the survivors, (Table 13) three quarters of those who went home were independent in walking (Rankin I-III). Only one of a total of 5 patients who went to long-term care achieved this grade.

TABLE 14

GROSS LOSS GROUP ON ADMISSION - SENSORY STATUS AT FIRST DISCHARGE RELATED TO PLACEMENT

Placement	Number	Sensory Status		
		Gross	Moderate	Slight
Home	8	3	4	1
Long-Term	5	3	1	1
Death	3	2	1	
TOTAL	16	8	6	2

When placement is related to the sensory status of the group on first discharge (Table 14), the surprising feature is that 3 out of the 6 survivors who remained in the gross loss group went home.

To Summarize the Gross Loss Group on Admission

1. Though half the patients in the gross group remained in this group by discharge, half had improved (so that improvement can occur even in the severely disabled stroke patient). Two out of the 16 patients actually moved up by two steps.
2. Age is not an insurmountable barrier to improvement.
3. Half of these patients went home and even of those patients who made no improvement and remained in the gross loss group by discharge, over one third went home.
4. Just over half the survivors were independent in walking on first discharge.
5. The majority of patients in this group (14 out of 16), had a left sided hemiplegia.

MODERATE LOSS GROUP ON ADMISSION

Referring once again to Table 8 (page 74), it can be seen that there were 11 patients in this group and their sensory status on first discharge is shown in Table 15.

TABLE 15

DISCHARGE SENSORY STATUS OF PATIENTS IN THE MODERATE LOSS GROUP ON ADMISSION (11 PATIENTS)

NUMBER OF MODALITIES		
MOD LOSS 4	SLIGHT LOSS 5 6 7	COMP RECOV 7 + Ster
Whi	Ada* Gil* Red Mer* Rob* Hal	Pal Mas McG For
TOTAL = 1	TOTAL = 6	TOTAL = 4

* Normal Stereognosis

One patient gained only one modality and remained in the moderate loss group by discharge but the improvement of the other 10 patients can be summarized as follows:

6 patients improved one step into the Slight Loss group.

4 patients improved two steps into the Complete Recovery group.

The interesting feature here is that of the 6 patients still in the slight loss group by first discharge, 4 had normal stereognosis. The absent modalities were two point discrimination and/or proprioception. On the other hand, one patient had 7 intact modalities but still had abnormal stereognosis.

Again, as in the gross loss group these patients were in three sensory groups by discharge and a summary of the essential features of these three groups can be seen in Table 16. All 11 patients went home.

TABLE 16

DISCHARGE SENSORY STATUS OF PATIENTS IN THE MODERATE LOSS GROUP ON ADMISSION (11 PATIENTS)

	No	Age in Years Mean ± SE	Sex M	Sex F	Side R	Side L	Days in Hosp Mean ± SE
Moderate	1	72.0		1		1	37.0
Slight	6	71.8 ±3.7	2	4	4	2	63.7 ±13.4
Comp Recov	4	73.5 ±4.4	3	1	3	1	98.0 ±14.0

It was difficult to make a valid comparison here with only one patient in the moderate loss group by first discharge, but the length of stay of the complete

recovery group was greater than the slight loss group. This may account for the fact that complete recovery did take place in these 4 patients.

TABLE 17

RANKIN DISABILITY GRADE ON FIRST DISCHARGE OF THE MODERATE LOSS GROUP ON ADMISSION (11 PATIENTS)

Sensory Status on Discharge	No	Rankin Grades		
		I+II	III	IV+V
Moderate	1		1	
Slight	6	2	3	1
Comp Recov	4	2	1	1
TOTAL	11	4	5	2

If we look at the Rankin disability grades achieved by this group (Table 17) it can be seen that only 2 out of 11 did not achieve grades I-III though in fact they all went home.

Summary of Moderate Loss Group

1. All 11 patients went home.
2. Nine out of 11 were independent in walking though less than half were independent in self-care.
3. Those who made a complete recovery were in hospital for longer than the average stay.

4. Patients with a right hemiplegia were in the majority.
5. Four patients had normal stereognosis by discharge without return of all modalities.

SLIGHT LOSS GROUP ON ADMISSION

TABLE 18

DISCHARGE SENSORY STATUS OF PATIENTS IN THE SLIGHT LOSS GROUP ON ADMISSION (4 PATIENTS)

NUMBER OF MODALITIES	
SLIGHT LOSS 6	COMP RECOV 7 + Ster
All	Rot Sau Kil
TOTAL = 1	TOTAL = 3

By comparing Table 8 with Table 18, the improvement of the 4 patients in this group can be observed:

One patient had a further stroke at thirty-five days.

3 patients improved one step to complete recovery.

TABLE 19

SURVIVORS OF SLIGHT LOSS GROUP ON ADMISSION (3 PATIENTS)

	Sex	Age in Years	Side	Days in Hosp	Rankin Grades
Rot	F	64	L	23	II
Sau	F	75	L	27	II
Kil	F	80	L	45	II

All made a complete recovery by first discharge. The 3 survivors were all female; went home; were independent in self-care (Rankin I-II); had a left hemiplegia and were in hospital for a relatively short time.

STUDY GROUP ON ADMISSION

Having looked in detail at each of the three sensory groups on admission, a summary of these can be seen in Table 20.

TABLE 20

STUDY GROUP ON ADMISSION (31 PATIENTS)

Sensory Status on Admission	No	Age in Years Mean ± SE	Sex M F	Side R L	Days in Hosp of Survivors Mean ± SE
Gross	16	72.7 ±1.5	5 11	2 14	80.3 ±7.8
Moderate	11	72.5 ±2.4	5 6	7 4	73.7 ±10.5
Slight	4	71.3 ±3.8	1 3	1 3	31.6
TOTAL	31	72.4	11 20	10 21	72.2

The outstanding feature was the length of stay. The moderate loss and gross loss groups were in hospital significantly longer than the slight loss group. Also out of the 10 patients with a right hemiplegia in the group, 7 were in the moderate loss group on admission where they were actually in the majority. Compared to patients with a left hemiplegia, proportionately more of the patients with a right hemiplegia were in the moderate and slight loss groups combined which is statistically significant ($p < 0.05$, Fisher's Exact Test).

TABLE 21

SENSORY STATUS ON ADMISSION RELATED TO PLACEMENT AT FIRST DISCHARGE OF STUDY GROUP

Sensory Status on Admission	No	PLACEMENT		
		Home	L.T. Care	Further Stroke/ Death
Gross	16	8	5	3
Moderate	11	11		
Slight	4	3		1
TOTAL	31	22	5	4

Perhaps as a result of a long time in hospital, all of the moderate group went home and also over two thirds of the survivors of the gross loss group (Table 21).

TABLE 22

RANKIN DISABILITY GRADE ON FIRST DISCHARGE OF SURVIVORS OF STUDY GROUP (27 PATIENTS)

Sensory Status on Admission	No	Rankin Grades		
		I+II	III	IV+V
Gross	13	4	3	6
Moderate	11	4	5	2
Slight	3	3		
TOTAL	27	11	8	8

This was matched by the Rankin disability grades where over three quarters of the moderate loss group were

independent in walking compared to just over half of the survivors of the gross loss group, (Table 22).

TABLE 23

SENSORY STATUS OF STUDY GROUP ON FIRST DISCHARGE

NUMBER OF MODALITIES								
GROSS LOSS		MOD LOSS			SLIGHT LOSS			COMP REC
0	1	2	3	4	5	6	7	7 + Ster
Art	Nis		Cum	McM	Lin	Glo	Red	Pal
Beg			Hun	Whi	Ada*	Hal		For
Wal			Wyl	Gre*	Mer*	Gil*		Mas
Nor			Fra			Rob*		Kil
Boy						All*‡		Rot
Rei								Sau
Gib								McG
TOTAL = 8		TOTAL = 7			TOTAL = 9			TOTAL = 7

[ ] = Death ‡ = Stroke before Discharge

* Normal Stereognosis

By referring to Tables 8 and 23 where the patients are listed according to their sensory status on admission and first discharge respectively the improvement of the study group as a whole can be summarized as follows:

10 patients made no improvement (includes 2 deaths and one further stroke).

15 patients improved by one step (includes one death).

6 patients improved by two steps.

The actual numbers in each group on admission and discharge are shown in Table 24 and the distribution of

the survivors into the sensory groups on admission and first discharge are in Table 25.

TABLE 24

SENSORY STATUS OF STUDY GROUP ON ADMISSION AND FIRST DISCHARGE (31 PATIENTS)

	Gross	Moderate	Slight	Comp Recov
Admission	16	11	4	
1st Disch	8	7	9	7

TABLE 25

SENSORY STATUS OF 27 SURVIVORS ON ADMISSION AND FIRST DISCHARGE

Sensory Status on 1st Disch	No	ON ADMISSION		
		Gross	Moderate	Slight
Gross	6	6		
Moderate	6	5	1	
Slight	8	2	6	
Comp Recov	7		4	3
TOTAL	27	13	11	3

Table 25 confirms that of the 6 patients who improved two steps, 2 of them came from the gross loss group. No patient in the total recovery group came from the group with gross loss on admission.

Summary of the Study Group Patients on Admission

1. The moderate loss group and the gross loss group required longer in hospital (more than twice the time for the slight loss group).
2. The prospect of discharge home for the moderate loss and slight loss groups was good. Even in the gross loss group half went home.
3. Of the groups as a whole including 3 deaths and one patient with a further stroke, 21/31 (68%) improved their sensory status by discharge.
4. A greater number of the moderate and slight loss groups were independent in walking (Rankin I-III) compared to the gross loss group.
5. A significantly larger number of the patients with a right hemiplegia were in the moderate and slight loss groups compared to the patients with a left hemiplegia.

The Study Group on First Discharge

Having considered the study group on admission, it is now appropriate to look at it on first discharge. Table 23 shows that the survivors fall into four groups as compared to three groups on admission. A summary of these four groups is in Table 26.

TABLE 26

SENSORY STATUS ON DISCHARGE - SUMMATION OF 27 SURVIVORS OF THE WHOLE STUDY GROUP

	No	Age in Years Mean ± SE	Sex M	Sex F	Side R	Side L	Days in Hosp Mean ± SE	Placement Home	Placement L.T.
Gross	6	70.2 ±2.7	3	3		6	77.5 ±12.9	3	3
Moderate	6	71.7 ±1.9	2	4		6	74.5 ±13.6	5	1
Slight	8	74.0 ±3.1	2	6	5	3	68.9 ±10.7	7	1
Comp Recov	7	73.3 ±3.0	3	4	3	4	69.6 ±15.6	7	

Patients with a right hemiplegia were all in the slight or complete recovery groups. There was little difference in length of hospital stay between the groups. The majority of patients in the moderate (83%) and slight (88%) loss groups went home along with all those with complete recovery. Only half the gross loss patients achieved home discharge.

This was matched by the Rankin disability grades where only half of the gross group were independent in walking compared to the moderate group with 67%, the slight group with 75% and the complete recovery group with 86% (Table 27).

TABLE 27

RANKIN DISABILITY ON FIRST DISCHARGE OF 27 SURVIVORS OF THE STUDY GROUP

Sensory Status on 1st Disch	No	Rankin Grades		
		I+II	III	IV+V
Gross	6	1	2	3
Moderate	6	2	2	2
Slight	8	3	3	2
Comp Recov	7	5	1	1

Summary of the Study Group on First Discharge

1. All patients with a right hemiplegia were in the slight or complete recovery groups.
2. Good prognosis for discharge home in the moderate, slight and complete recovery groups.
3. A greater number of the moderate, slight and complete recovery groups were independent in walking compared to the gross loss group.

THE STUDY GROUP AT SECOND DISCHARGE

When the entire study group is listed according to the number of modalities present and the sensory status at second discharge, it can be seen that a total of 25 patients were under review (Table 28).

TABLE 28

TOTAL OF 25 PATIENTS AT SECOND DISCHARGE

NUMBER OF MODALITIES					
GROSS LOSS 0 1	MODERATE LOSS 2 3 4	SLIGHT LOSS 5 6 7	COMP REC 7 + Ster	Not Followed up
Beg Nor Art Nis	Wyl McM Fra Hun Cum	Ada Red Gil Glo Lin Whi Wal	Pal For Mas Kil Rot Sau McG Mer Rob	Hal[1] Gib[2] Gre Rei Boy All[3]
TOT = 4	TOT = 5	TOT = 7	TOT = 9	TOT = 6

☐ = Death

1 = Not followed up for reasons of distance

2 = Not followed up for psychiatric reasons

3 = Stroke before discharge

Of the 6 who were not followed up, 3 had died and one took a further stroke before first discharge, one

patient moved away and one became untestable for psychiatric reasons.

It has already been shown (Table 23) that 7 patients made a complete recovery by the time of first discharge so that out of the 25 patients at second discharge, 18 had been routinely tested on a monthly basis after first discharge. Of these 18 patients, one died at eight months and another took a second stroke at ten months.

The 18 patients fall, as before, into four distinct sensory groups and a summary of their characteristics can be seen in Table 29 along with those of the 7 patients who made a complete recovery by first discharge.

TABLE 29

18 PATIENTS AT SECOND DISCHARGE

Sensory Status on 2nd Disch	No	Age in Years Mean ± SE	Side		PLACEMENT			
					1st Disch		2nd Disch	
			R	L	Home	L.T.	Home	L.T.
Gross	4	72.5 ±3.3		4	2	2	2	2
Moderate	5	71.6 ±2.3		5	4	1	4	1
Slight	7	73.7 ±3.4	3	4	6	1	6	1
Comp Recov	2	73.0	1	1	2		2	
TOTAL	18	72.7	4	14	14	4	14	4
7 PATIENTS WITH COMP RECOV BY 1st DISCHARGE								
	7	73.3 ±3.0	3	4	7		7	

The outstanding feature is that the placement of patients followed up remained the same as it was at first discharge. In other words, of the 25 patients followed up after discharge from hospital, all those who went home were still at home one year later.

TABLE 30

PATIENTS WITH PERSISTENT SENSORY LOSS AT FIRST DISCHARGE (18 PATIENTS)

Patient	RANKIN GRADES		PLACEMENT	
	1st Disch	2nd Disch	1st Disch	2nd Disch
1. Nis	IV	IV	LT	LT
2. Art	IV	II	H	H
3. Mer	II	II	H	H
4. Ada	III	II	H	H
5. Rob	IV	IV	H	H
6. Whi	III	III	H	H
7. Beg	IV	IV	LT	LT
8. Wyl	III	III	H	H
9. Cum	II	III	H	H
10. Nor	II	II	H	H
11. Gil	II	II	H	H
12. Wal	III	III	H	H
13. Hun	II	II	H	H
14. McM	IV	III	H	H
15. Fra	IV	IV	LT	LT
16. Lin	IV	IV	LT	LT
17. Glo	II	II	H	H
18. Red	III	III	H	H

Also, as can be seen in Table 30, all the patients except one maintained the functional level they had achieved by first discharge and in fact, 3 had improved. The one patient who did not maintain his functional level was still independent in walking.

TABLE 31

NUMBER IN SENSORY GROUPS AT ADMISSION, FIRST DISCHARGE AND SECOND DISCHARGE (18 PATIENTS)

	Gross	Moderate	Slight	Comp Rec
Admission	12	6		
1st Discharge	5	6	7	
2nd Discharge	4	5	7	2

The actual numbers in each group at the three points in time (admission, first discharge and second discharge), are shown in Table 31 and the breakdown of these numbers into sensory groups on admission and second discharge are in Table 32.

TABLE 32

SENSORY STATUS ON ADMISSION AND SECOND DISCHARGE (18 PATIENTS)

Second Discharge		Admission		
Sensory Status	No	Gross	Moderate	Slight
Gross	4	4		
Moderate	5	5		
Slight	7	3	4	
Comp Recovery	2		2	

By referring to Tables 8 (page 74), 23 (page 89), and 28 (page 94) where the patients are listed in their sensory groups on admission, first discharge and second discharge, the improvement of the 18 patients can be seen and summarized as follows:

From admission to second discharge

4 made no improvement

9 improved by one step

5 improved by two steps.

From first discharge to second discharge

14 made no improvement

3 improved by one step

one improved by two steps.

Table 31 and the summary above show that maximum improvement had occurred by first discharge. Table 32 also confirms that no patient in the gross group on

admission made a complete recovery even by the time of second discharge.

INDIVIDUAL MODALITIES PRESENT ON ADMISSION, FIRST DISCHARGE AND SECOND DISCHARGE

The study group was examined to determine the numbers of patients who had a particular modality on admission, first discharge and second discharge. The patients were looked at in various groups as before, i.e. the whole group, the gross loss group on admission, etc. and the numbers who had a particular modality are expressed as a percentage of the group in question in Bar Charts 1-6.

Each chart represents a particular group and all seven modalities tested are shown along with stereognosis, grip and two point discrimination in the unaffected hand. Each bar representing an individual modality shows the percentage of the group under study which had the modality on admission, the percentage which had it by first discharge and the percentage which did not.

Study Group (31 Patients)

If we look at Chart 1 where the study group of 31 patients is shown up to first discharge, out of a possible total of 217 modalities, the group had 58 on admission and 127 by first discharge. In this group, 35% had texture and 42% had size and tickle compared to a much smaller percentage which had weight (19%), shape (13%), proprioception (19%) and two point

CHART 1

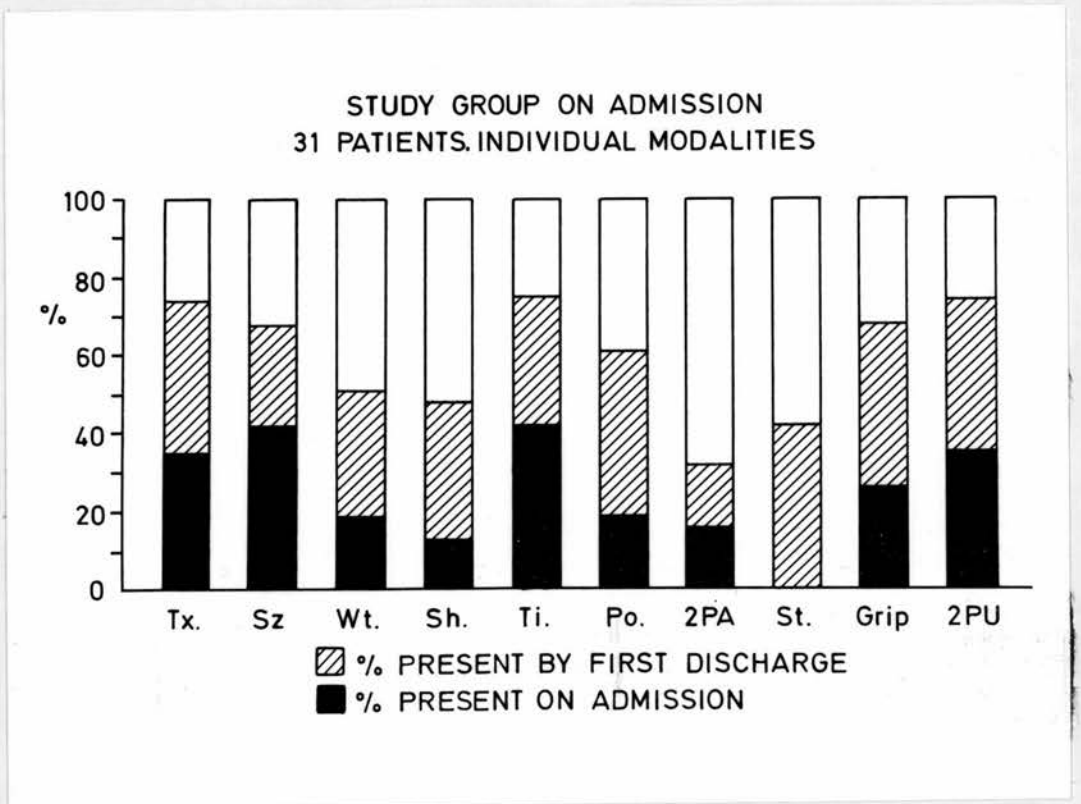
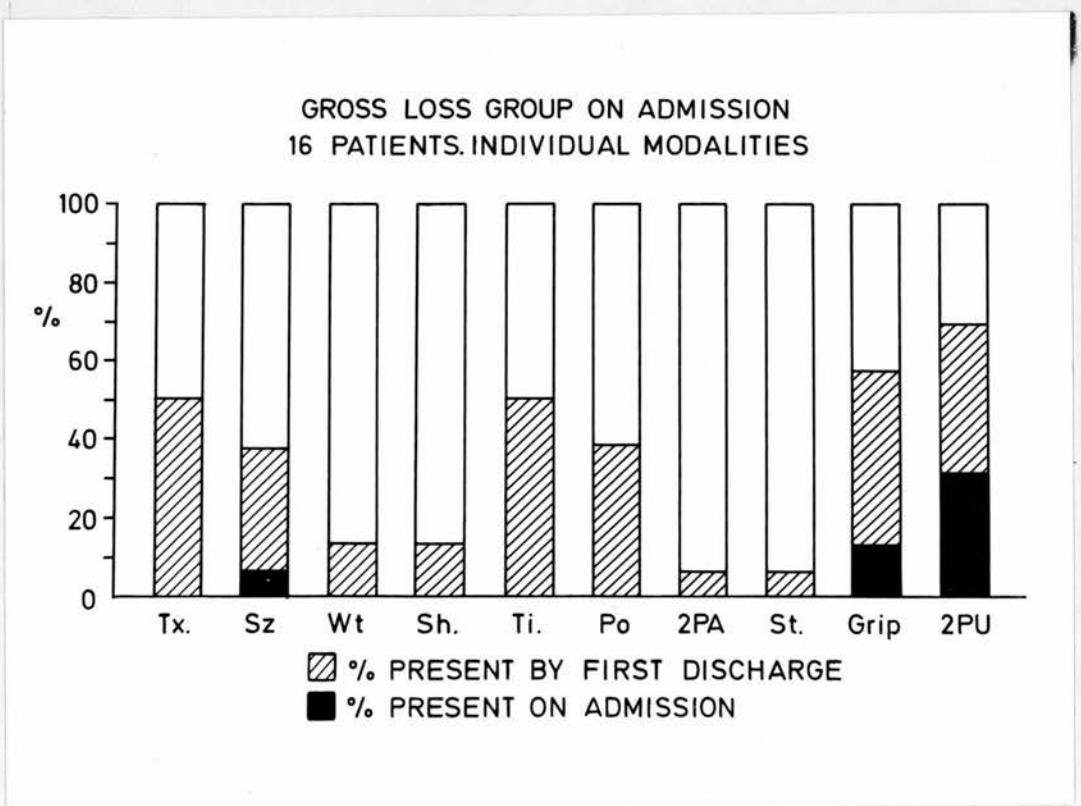


CHART 2



discrimination (16%).

By first discharge the same picture is to be seen with 74% having texture, 68% size and 75% tickle compared to a smaller percentage having weight (51%), shape (48%) and in particular two point discrimination with only 32%.

It seems clear therefore that texture, size and tickle are the modalities most likely to remain intact at the onset of the stroke and two point discrimination the one most likely to be absent at first discharge.

Two point discrimination in the unaffected hand was present to the same extent as texture, size and tickle in the affected hand, the most significant fact being that by first discharge the percentage who had the modality had increased to only 74%.

Gross Loss Group (16 Patients)

Chart 2 shows the gross loss group which had one modality on admission, out of a possible total of 112, but a total of 33 by first discharge. Size is the only modality represented on admission (6%).

The percentage of the group having each modality by first discharge showed a similar picture to the whole study group with 50% having texture and tickle, 37% having size and proprioception, 13% having weight and shape and only 6% having two point discrimination in the

affected hand.

A greater percentage of the group had two point discrimination in the unaffected hand on admission (31%), which increased to 69% by first discharge.

Moderate Loss Group (11 Patients)

The moderate loss group (Chart 3) had 33 modalities on admission, out of a possible total of 77, and 67 by first discharge. On admission, 64%, 73% and 82% had texture, size and tickle respectively compared to 36%, 9%, 18% and 18% who had weight, shape, proprioception and two point discrimination in the affected hand.

By first discharge, texture, size and tickle had fully recovered in this group and the percentage who had weight, shape and proprioception was 91%, 82% and 82% respectively. Only 54% had two point discrimination in the affected hand.

In the unaffected hand 27% had the modality on admission and this increased to 72% by first discharge.

Slight Loss Group (4 Patients)

The slight loss group (Chart 4) had 24 modalities on admission, out of a possible 28, and 27 by first discharge.

Texture, size, tickle and proprioception were all present on admission with weight and shape making a full

CHART 3

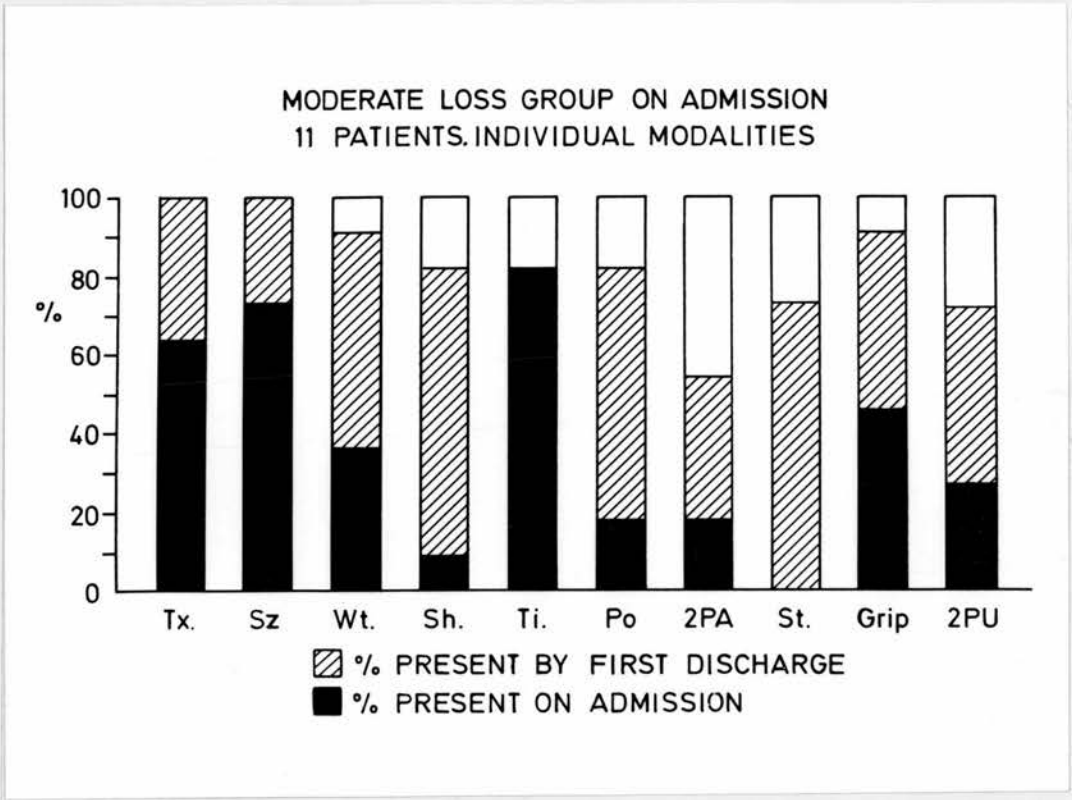
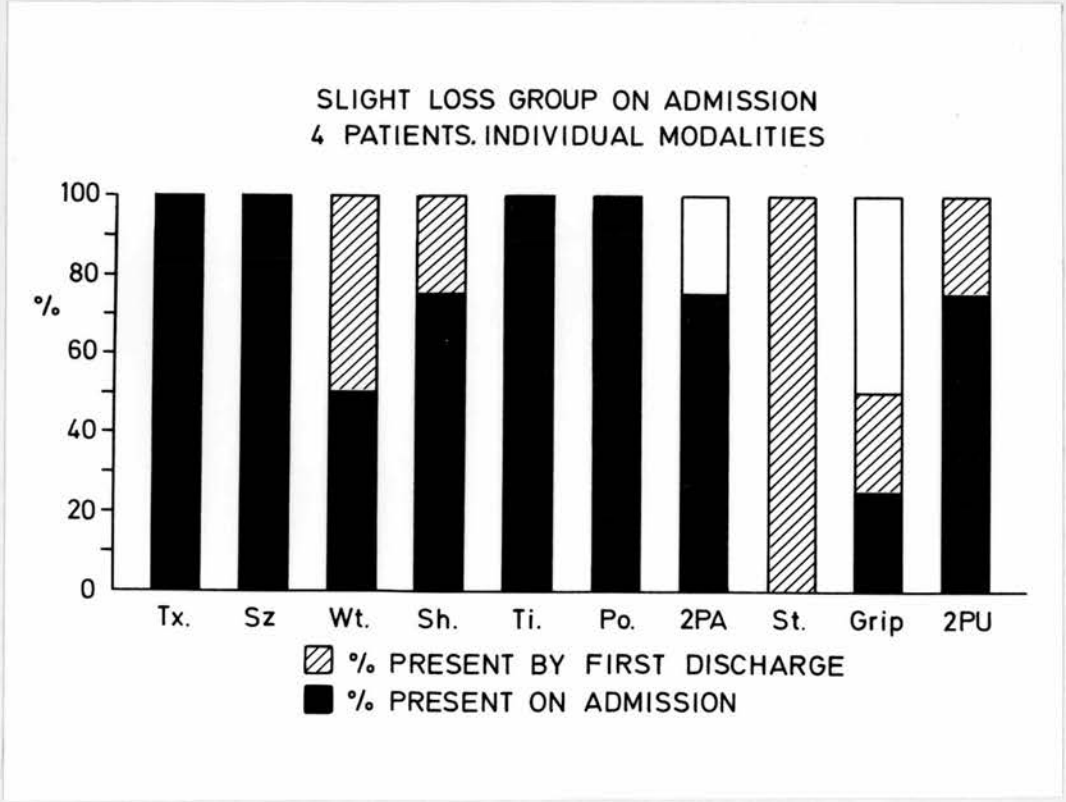


CHART 4



recovery. Two point discrimination in the affected hand was the only modality not to make a full recovery.

It can also be observed that this whole group had normal stereognosis by first discharge but half the patients still had a flaccid hand.

To Summarize Therefore:

1. When there is a partial loss of sensation, texture, size and tickle are most likely to be spared.
2. When there is a total loss of discriminative sensation, texture, size, tickle and proprioception are most likely to recover.
3. The appreciation of weight, shape and two point discrimination are never present in the absence of texture, size, tickle and proprioception.
4. Two point discrimination in the affected hand is least likely to recover.
5. Two point discrimination in the non-paralysed hand was affected in all groups (but not necessarily in every patient).
6. The ability to appreciate the size of objects can exist in the absence of normal proprioception.

The patients who were followed up for one year can be looked at in two groups.

The first (Chart 5) consists of 18 patients who had

CHART 5

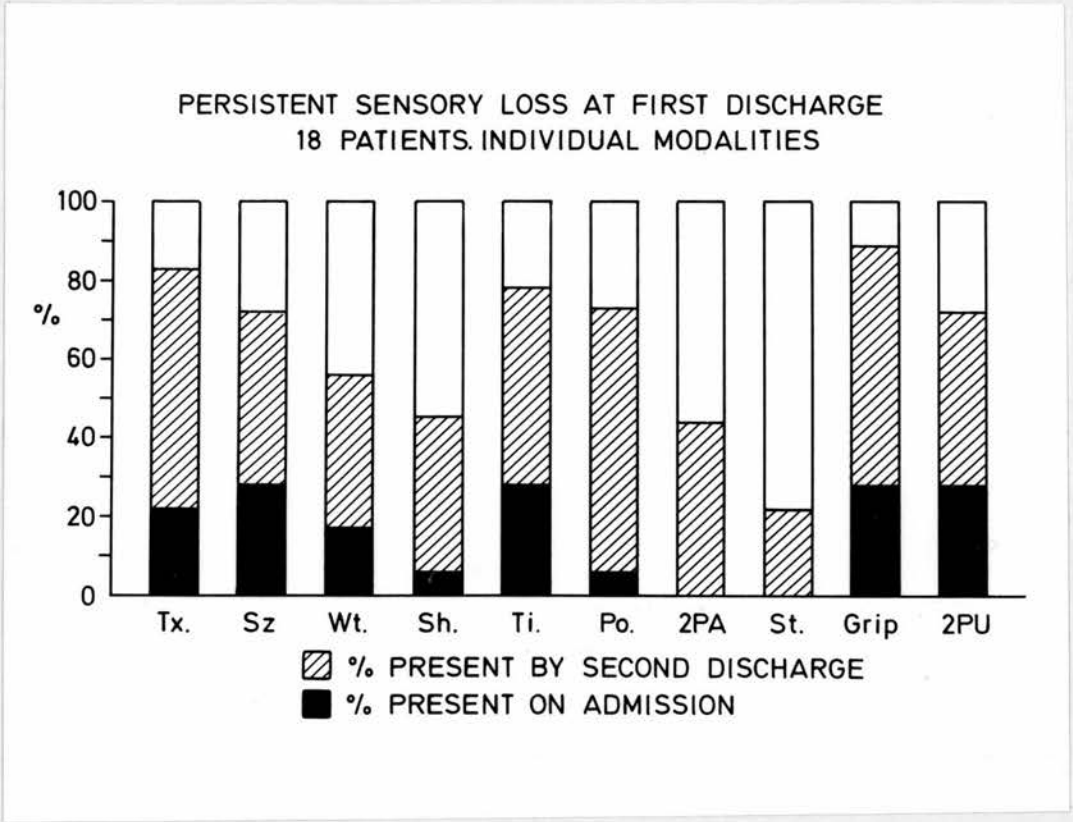
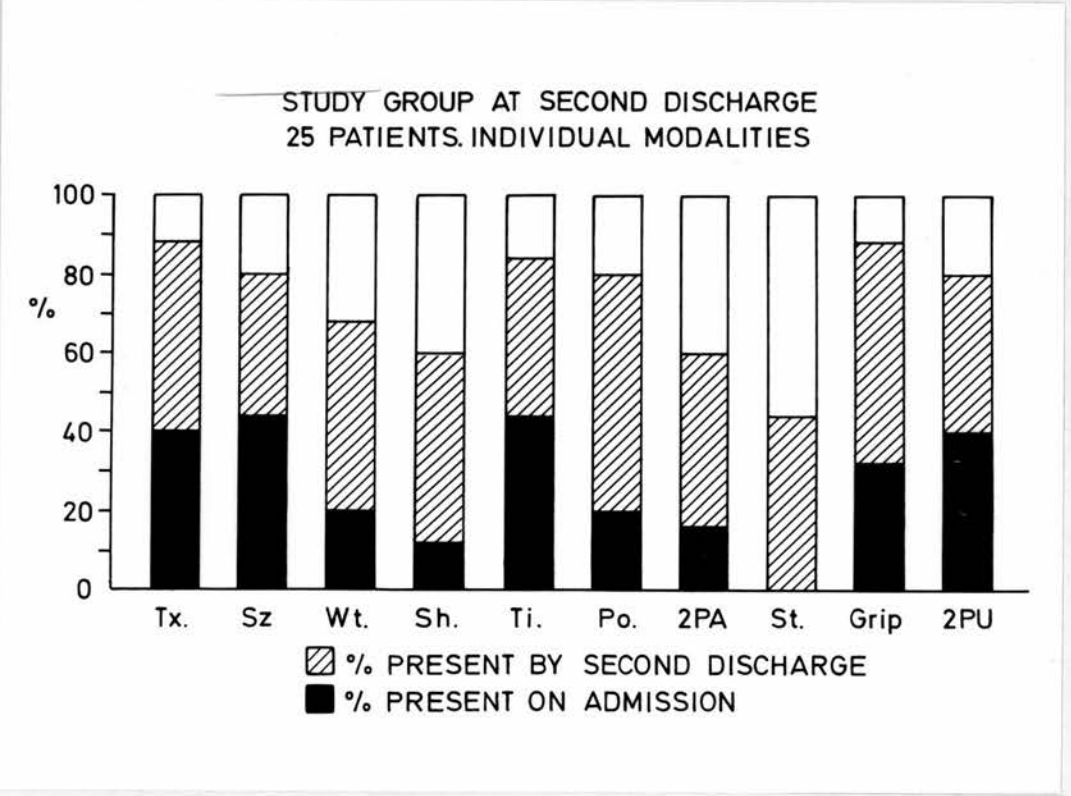


CHART 6



persistent sensory loss by first discharge. Of a possible total of 126 modalities, the group had 19 on admission and 81 on second discharge. As might be expected 22%, 28% and 28% had texture, size and tickle on admission compared to weight (17%), shape (6%) and proprioception (6%). No patient in this group had two point discrimination in the affected hand.

At the end of one year, 83% had texture, 72% size and 78% tickle. The percentage of patients with proprioception increased to 73% whereas only 56% had weight, 45% shape and 44% two point discrimination in the affected hand.

The percentage having two point discrimination in the unaffected hand increased from 28% on admission to 72% on discharge.

Chart 6 shows the 25 patients in the whole group followed up for one year. This includes the 18 who had not recovered by first discharge as in Chart 5 and the 7 who had recovered. Of a possible total of 175 modalities, the group as a whole had 49 modalities on admission and a total of 130 by second discharge. On admission, 40% of the group had texture and 44% size and tickle, but only 20% had weight, 12% shape, 20% proprioception and 16% two point discrimination in the affected hand.

By second discharge the percentage having texture, size, tickle and proprioception was 88%, 80%, 84% and 80% respectively compared to shape (60%), weight (68%) and two point discrimination (60%).

The proportion of the group which still did not have two point discrimination in the unaffected hand by the end of the year was 20%.

To Summarize:

1. On admission, texture, size and tickle were the modalities most likely to be retained in patients with partial loss of sensation.
2. By second discharge and where there has been gross loss of sensation, texture, size, tickle and proprioception are the modalities most likely to have returned.
3. Weight, shape and two point discrimination in the affected hand are the modalities least likely to return.
4. Two point discrimination in the non-paralysed hand was also affected in all groups.

THE TIME OF RECOVERY OF INDIVIDUAL MODALITIES

The time taken for recovery to occur in modalities which returned to normal is shown in Scattergrams A and B. In one patient this was not recorded so that Scattergram A is of 30 patients up to first discharge and Scattergram B is of the 24 patients followed up for one year.

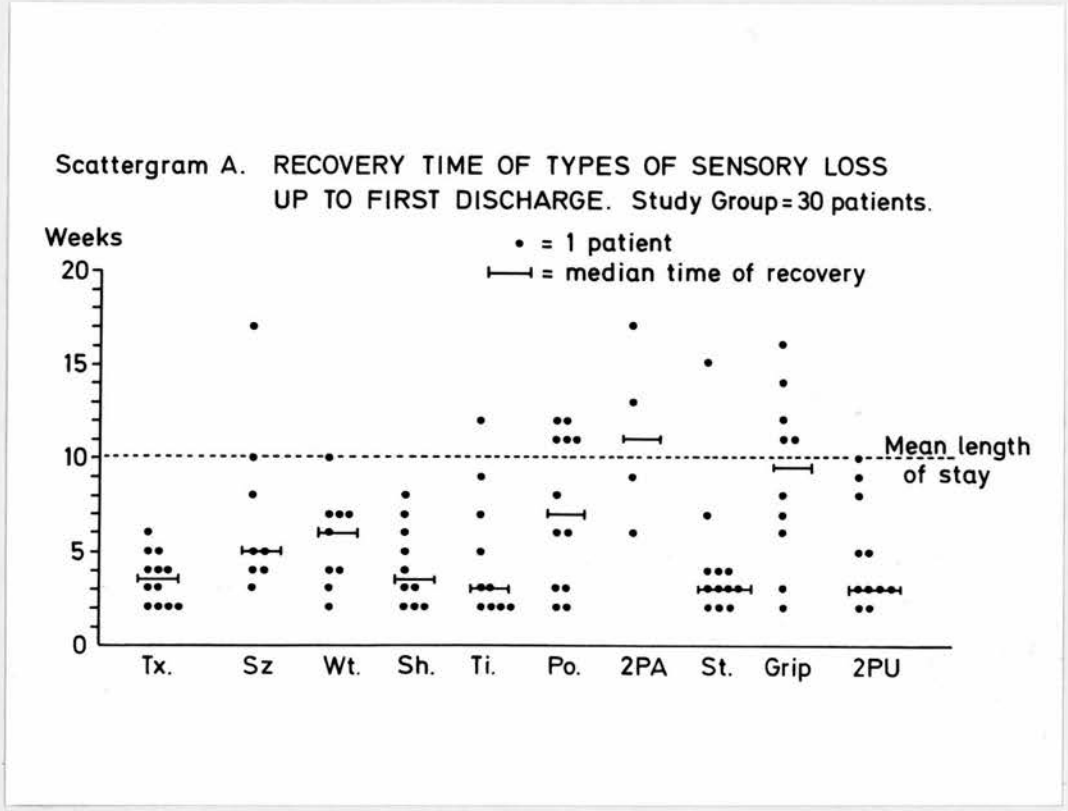
Scattergram A

The mean length of stay was 10.3 weeks and it can be observed that the majority of modalities which became normal by first discharge, had done so by then.

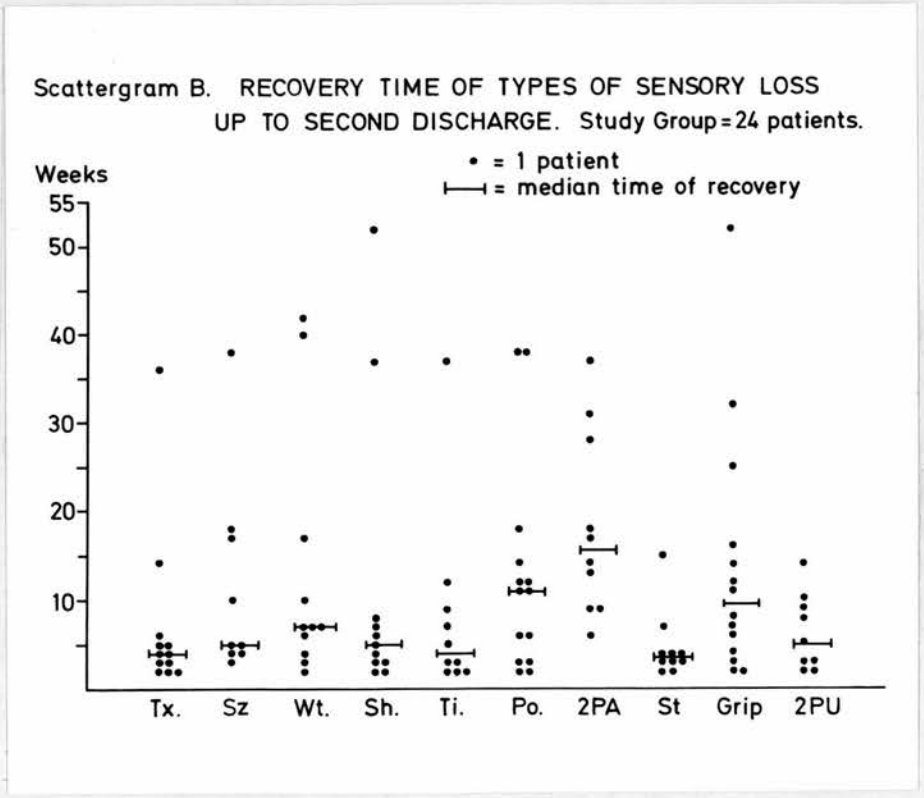
Three intervals were selected so that of the total number of modalities which had returned to normal, the proportion which had done so by four weeks, eight weeks and thirteen weeks (three months) could be calculated. Of the 7 modalities tested in the 30 patients, a total of 65 modalities had returned to normal by first discharge. Out of this total of 65 - 32 (49%) had returned by four weeks;
52 (80%) had returned by eight weeks;
63 (97%) had returned by thirteen weeks (three months).

If we include stereognosis and two point discrimination in the unaffected hand with the 7 modalities tested,

SCATTERGRAM A



SCATTERGRAM B



88 modalities had returned to normal by first discharge.
Of this total of 88 - 48 (55%) had returned by four weeks;
72 (82%) had returned by eight weeks;
85 (97%) had returned by thirteen weeks (three months).

Scattergram B

This is of 24 patients who were still in the group at one year of which 18 had not recovered by first discharge and were followed up for the year. This confirms the impression that if recovery is going to occur, then it will do so by three months with the greater part taking place before that time.

Of the 7 modalities tested in the 24 patients, 77 had returned by second discharge.
Out of this total of 77 - 45 (58%) had returned by two months;
56 (73%) had returned by three months;
65 (84%) had returned by six months.
So that after six months only 16% recovered.

If we include stereognosis and two point discrimination in the unaffected hand with the 7 modalities tested

then out of a total of 96 modalities tested:

60 (63%) had recovered by two months;

73 (76%) had recovered by three months;

84 (88%) had recovered by six months.

So that after six months only 12% recovered.

Conclusions

The two scattergrams demonstrate that if recovery is going to take place, it will do so in the first few weeks and 75% of these modalities which will return to normal will have done so by three months with very little recovery after six months.

Median Time of Recovery

The horizontal lines on the scattergrams represent the median time of recovery of each individual modality. Remembering that the scattergrams represent only those modalities which have actually returned to normal, without any reference to those which were unaffected on admission, we can see in scattergram A in particular, that texture, shape and tickle were the first to recover with size, weight and proprioception second and two point discrimination in the affected hand a long way behind. Stereognosis and two point discrimination in the unaffected hand recovered at the same time as texture, shape and tickle.

STEREOGNOSIS SCORE RELATED TO NUMBER OF MODALITIES PRESENT

An attempt was made to see if there was any association between the maximum stereognosis score and the number of modalities present.

In Table 33 the patients have been grouped according to their maximum stereognosis scores as follows:

Group 1 = Stereognosis score of 0 (4 patients);

Group 2 = Stereognosis score of 1, 2 or 3 (10 patients);

Group 3 = Stereognosis score of 4 or 5 (4 patients);

Group 4 = Stereognosis score of 6 (13 patients).

Group 1

The stereognosis score in these patients was 0 yet one of them had 4 modalities and 3 had grip.

Group 2

Two out of the 10 patients in this group had 5 and 6 modalities respectively but their stereognosis scores were only 2 and 3 respectively. In this group the modalities predominantly present were texture, and tickle which is in keeping with the observations made previously.

Group 3

The feature to be noted in this group of patients is that in spite of having 4, 6 or 7 modalities, the maximum

TABLE 33

THE ASSOCIATION OF THE MAXIMUM STEREOGNOSIS SCORE AND THE NUMBER OF MODALITIES PRESENT IN EACH PATIENT

	No of Mods	Tex	Siz	Wei	Sha	Tic	Pro	2 pnt Dis A	Grip	2 pnt Dis U
Stereognosis Score = 0										
Boy	0	-	-	-	-	-	-	-	-	+
Rei	0	-	-	-	-	-	1	-	+	1
Gib	1	-	-	-	-	-	+	1	+	+
Fra	4	+	+	-	-	+	+	1	+	+
Stereognosis Score = 1, 2 or 3										
Beg	0	-	-	-	-	-	1	1	-	+
Art	0	-	-	-	-	-	1	1	+	-
Nor	0	-	-	-	-	-	1	2	+	+
Nis	1	+	-	-	-	-	1	1	-	+
Hun	3	+	-	-	-	+	1	+	+	+
McM	3	+	-	-	-	+	+	1	+	-
Lin	5	+	+	+	-	+	+	2	-	+
Cum	2	+	-	-	-	+	1	1	-	+
Wyl	3	+	+	-	-	+	2	1	+	-
Wal	6	+	+	+	+	+	+	1	+	+
Stereognosis Score = 4 or 5										
Whi	4	+	+	-	½	+	+	2	+	+
Hal	6	+	+	+	-	+	+	+	-	+
Red	6	+	+	+	+	+	+	2	-	+
Glo	7	+	+	+	+	+	+	+	+	+
Stereognosis Score = 6										
Ada	4	-	+	+	+	+	1	1	+	1
Mer	4	+	+	+	½	+	1	2	+	2
Rob	4	+	+	-	½	+	+	1	-	+
Gre	4	+	+	-	+	+	1	1	-	1
All	6	+	+	+	+	+	+	2	-	2
Gil	6	+	+	+	+	+	+	1	+	1
Mas	6	+	+	+	+	+	+	2	-	+
6 pats with intact mods (one with a flaccid hand)										

\+ = Normal
\- = Abnormal or absent

Actual scores shown in shape, prop. and 2 pnt discrimination

stereognosis score was never gained. Even in the patient with 7 modalities and the ability to grip, the stereognosis score was still only 5. The modalities predominantly absent in this group were weight, shape and two point discrimination.

Group 4

The patients can be considered in two separate groups: those who had a full return of modalities (6 patients - one had a flaccid hand); and those where there was not a full return of modalities (7 patients). In the latter group, 4 out of the 7 patients had only 4 modalities present - size and tickle being the only modalities intact. In all 4, two point discrimination was absent and only one had proprioception, the score of the remaining 3 patients being only one. The 3 patients who had 6 modalities, all lacked two point discrimination.

The most marked feature in these 7 patients was that 4 had a flaccid hand which made a total of 5 in this group of 13 patients.

Conclusions

1. These results show that stereognosis can vary independently of other types of discriminative sensation. It may be normal when only 4 modalities are present but it may be absent when there are 5, 6 or 7

modalities. Stereognosis probably has a distinctive cortical representation.

2. Two point discrimination and proprioception (as tested in this study) are not essential for intact stereognosis. This was also shown in the normal group (B) on admission (page 71).

3. Intact stereognosis can be present in a flaccid hand.

TWO POINT DISCRIMINATION

By referring to Table 34 it can be seen that only 16% of the study group of 31 patient had normal two point discrimination in their affected hand at the onset of the stroke and a further 16% recovered this modality by first discharge in a median time of eleven weeks. By comparison, 35% had normal two point discrimination in the unaffected hand on admission and a further 39% recovered in a median time of only three weeks by first discharge.

TABLE 34

STUDY GROUP OF 31 PATIENTS

	No of patients with normal 2 pnt discrimination		No of pats who recovd normal discrim by 1st disch	Median time of Recovery
	Admission	1st Disch		
Aff Hand	5 (16%)	10	5 (16%)	11 weeks
Unaff Hand	11 (35%)	23	12 (39%)	3 weeks
25 patients followed up (for 1 year) to 2nd disch				
Aff Hand	4 (16%)	15	11 (44%)	15.5 wks
Unaff Hand	10 (40%)	20	10 (40%)	5 weeks

A similar picture may be seen when we look at the 25 patients followed up for one year. The time of recovery on the affected side was again three times that on the unaffected side.

Depending on whether one or both hands lost two point discrimination the 31 patients can be classified as follows:

1. In 4 (13%) patients the modality was normal in both hands (Group 1).
2. In 7 (23%) patients the modality was normal in the unaffected hand but lost in the affected hand.
   Of the 7 patients - 4 regained the modality (Group 2a);
   3 did not regain the modality (Group 2b).
3. In 19 (61%) patients both hands had lost the modality.
   Of the 19 patients - 7 regained the modality in both hands (Group 3a);
   5 regained the modality in the unaffected hand only (Group 3b);
   7 did not regain the modality in either hand (Group 3c).
4. In one patient only, the modality was lost on the unaffected side but retained on the affected side.

All patients in the study group are included in this classification though it has to be remembered that by dying, some patients had no opportunity to show whether they would have recovered the modality or not. The same is true of those patients who might have recovered the modality later than one year after the onset

of the stroke. It can be further noted that apart from the one patient in Group 4, the unaffected side always returned to normal before the affected side and that no patient regained two point discrimination in the affected hand without the unaffected hand being normal.

The placement of the patients in these groups (except for the patient in Group 4) is shown in Table 35.

TABLE 35

	PLACEMENT AT ONE YEAR		
	Home	L.T.	Further Stroke/Death
Group 1 = 4	4		
Group 2a = 4	3		1
Group 2b = 3		1	2
Group 3a = 7	6	1	
Group 3b = 5	2	2	1
Group 3c = 7	5		2

As shown above (not including the patient who lost the modality on the unaffected hand only) we have six groups of patients depending on whether one or both hands retained or regained the modality. These six groups can be divided into two sections as follows:

Groups 1, 2a and 3a (15 patients) - All those patients who either retained or regained the modality

in each hand.

Groups 2b, 3b and 3c (15 patients) - Those patients who did not regain the modality in the affected hand.

TABLE 36

	Home	L.T.	Further Stroke/Death
Groups 1 + 2a + 3a	13	1	1
Groups 2b + 3b + 3c	7	3	5

By matching these two groups with their placement at one year (Table 36) it may be seen that the recovery of two point discrimination might well be an important prognostic factor.

Groups 1, 2a and 3a have almost twice the number of patients who were still at home at the end of one year as compared to Groups 2b, 3b and 3c which have a greater number of deaths and long-term patients.

CHAPTER 11

DISCUSSION

DISCUSSION

The importance of careful sensory testing after cerebral damage has been emphasised for many years, (Head and Holmes, 1911; Critchley, 1962; Allison, 1962). In spite of this, it receives scant attention by the clinician. It is only relatively recently that the importance of sensory defect in the rehabilitation of stroke and the recovery of function has been recognised, (Twitchell, 1957; Adams and Hurwitz, 1963; Harris, 1964; Adams, 1966; Hurwitz, 1966; Isaacs and Marks, 1973).

When it is considered that there appear to be only two studies into the return of motor power after a stroke, (Twitchell, 1951; Buskirk, 1954), it is not surprising that information in the literature about the return of discriminative sensation is virtually non-existent.

This lack of knowledge of the effect of sensory loss on recovery of function after a stroke was demonstrated by Marquardsen (1969), who quoted one reference only on sensation in his extensive review of the literature, and also by Adams (1974). In spite of this lack of published data several authors have noted that a severe sensory deficit is associated with poor recovery.

None of the three investigations into the recovery of sensory loss after a stroke are comparable with this study. Buskirk and Webster (1955) followed their stroke

patients from the time when they entered the rehabilitation unit which did not always coincide with the onset of the stroke. In one patient it was seven years after the stroke. Only 3 sensory modalities were followed up: pain, vibration sense and two point discrimination and the age of the patients varied from 31 to 76 years. Fugl-Meyer et al (1975) in their evaluation of the return of motor function after a stroke, followed up their patients from one week after the onset of the stroke for one year and included 2 sensory modalities, proprioception and light touch. These patients had not been selected from the point of view of their reliability for sensory testing and the results are therefore difficult to evaluate due to poor co-operation and problems with aphasia. Newman's study (1972) into the recovery of 39 stroke patients is perhaps more comparable with the present investigation. His patients were all admitted to a rehabilitation unit within four weeks of the onset of the stroke, were followed up weekly for at least twenty weeks and tests for two point discrimination and proprioception were included in the standard neurological evaluation. However, he does not state whether all his patients were suitable for sensory testing and as 19 out of his 25 patients with a right hemiplegia had a language problem and others had impaired mental function, there must have been some who were untestable.

It was clear therefore that there was a gap in the present knowledge of stroke patients and that the patients entered into the Edinburgh Stroke Rehabilitation Study provided an opportunity to study sensory loss and its recovery and to relate this recovery (or the lack of it) to the eventual functional status and the final placement of the patient.

There were many difficulties in this investigation and most of them centred on the fact that all testing, to be worthwhile, was totally dependent on patient co-operation and reliability. Every effort had to be made to ensure this and as a result the investigation required great patience, tolerance and was extremely time-consuming. In order to ensure that all patients were tested under similar conditions, only those in the Edinburgh Stroke Rehabilitation Study admitted to the Royal Victoria Hospital Stroke Unit were included. It was difficult to envisage at the start of the project just how many patients would be found to be suitable for follow-up testing of sensation. As only 4 or 5 patients on average were admitted to the stroke unit each month, it was perhaps fortunate that 31 patients were eventually collected (by the end of the Edinburgh Stroke Rehabilitation Study) who had not only a discriminative sensory deficit, but were also suitable for serial testing.

A larger number would have been desirable but after working in this field it can be said that this would be difficult to achieve unless working for a longer period in a stroke unit with an admitting policy similar to that in the Edinburgh Stroke Rehabilitation Study. It is a common belief that there are large numbers of stroke patients regularly admitted to hospital. This is undoubtedly true, but what is not always realised is that many of these patients survive to occupy their hospital beds for many weeks giving the impression that there are many more strokes admitted than is actually the case (Thomson, 1971). Also, to add to the difficulties of carrying out this type of investigation, it must be remembered that a proportion of strokes are mild and recovery rapidly, others die within a short time of the onset of the stroke and in the elderly in particular, pre-stroke pathology may complicate the final clinical picture. The numbers of 'uncomplicated' stroke patients who have an unclouded consciousness without significant mental impairment are relatively few.

The criteria of selection for entry into the Edinburgh Stroke Rehabilitation Study meant that all strokes admitted to the Royal Victoria Hospital Stroke Unit had a paralysis severe enough to prevent them from walking. Therefore, a sensory deficit indicated an additional complication and a more extensive stroke.

It might therefore be said that those patients in the study group had more problems than those without sensory loss.

This is evident when comparing the normal group (i.e. those without discriminative loss) on admission with the study group. The patients in the first group were in hospital for half as long as the study group, a greater proportion of them went home on first discharge as opposed to long term care and more were walking independently (Rankin I-III). When we look at those who went home independent in self-care (Rankin I and II) there were more than twice the number in the normal group compared to the study group.

Here of course we are referring to sensory loss on admission as opposed to a proved persistent sensory deficit and it is difficult to find comparable figures or to assess the number of strokes entering acute medical units with sensory loss at the onset of the stroke. Sensory loss at the onset of a stroke is considered unimportant compared to other physical signs in assessing prognosis for immediate survival as opposed to prognosis for functional recovery, (Marquardsen, 1969). As a result, sensory examination is often limited and not repeated. It is only when the patient survives and is able to begin rehabilitation that sensory deficit may be noted and followed up.

Of patients entering the stroke unit, just under a third were untestable. Therefore the conclusions of this study are based on the findings in patients who were testable. Thirty-one of the 77 patients (44%) had loss of sensation and this was accompanied by a bad prognosis for length of stay in hospital. The prospect of home discharge and of eventual recovery of function was considerably reduced in patients with loss of sensation as compared to those without sensory loss.

These findings are at variance with those of Marquardsen (1969) who found that in strokes examined for sensory loss of a cortical type on admission, there was virtually no difference in the functional outcome between this group and the group with unimpaired sensation. Even when he compared two groups of patients with total or severe hemiplegia, the outcome in those with sensory loss on admission was identical to that of the normal group. In his series, sensation was recorded in 399 patients and 130 (38%) were found to have sensory loss on admission.

If the individual sensory groups on admission are examined instead of the study group as a whole, it is evident that the gross loss group fared less well than the moderate or slight loss groups. Though the length of stay of the gross and moderate groups were virtually identical, in all other respects the moderate loss group

did better in that all the patients achieved home discharge compared to only half the gross loss group and 82% were independent in walking (Rankin I-III) compared to 54% of the survivors of the gross group. The slight loss group on admission, as might be expected, performed better all round in that all 3 survivors went home, were independent in self-care (Rankin I-II) and their length of stay was less than half that of the other two groups.

In addition it should be noted that all the deaths in the study group by first discharge came from the gross loss group, so it can be said that gross loss of sensation at the onset of a stroke indicates a poor prognosis for home discharge, length of stay in hospital, eventual functional recovery and also for survival compared to a moderate or slight loss of sensation.

However, in view of the general impression given in the literature that sensory loss is associated more often than not with poor recovery and difficulty in rehabilitation, it is important to remember, especially when dealing with this type of neurological deficit, that half of the gross loss group <u>did</u> in fact achieve home discharge and in addition half of the survivors became independent in walking.

The effect of <u>persistent</u> sensory loss can be observed in the sensory groups at first discharge. The interesting

feature is that of patients discharged home there is no marked difference between the groups for length of stay in hospital - even the complete recovery group was in hospital for almost as long as the gross loss group. This finding is opposite to that of Buskirk and Webster (1955) who found that those patients with persistent sensory loss were in hospital three times as long as those who recovered sensation.

However the group with persistent gross loss of sensation performed markedly less well in that only half of the group went home and became independent in walking compared to much higher proportions in the other groups. This agrees with Buskirk and Webster who found that the majority of patients with no recovery of sensation achieved a poor result after rehabilitation. Stern et al (1971) who included two point discrimination in his battery of tests also emphasised the poor functional outcome in patients with hemisensory loss after hemiplegia. Feigenson et al (1977) however, in two studies into the factors influencing outcome of rehabilitation after stroke did not support this view but did not define what constituted hemisensory loss.

However, if those patients with persistent sensory loss at first discharge are studied at second discharge, the important finding is that in all 18 patients, the placement was the same as at first discharge and, except

for one, the level of function had been maintained and even improved upon in 3 cases. In the one exception, the level of function had only fallen from Rankin II to Rankin III and the patient was still independent in walking.

It would appear therefore that though persistent sensory loss is a definite handicap in the rehabilitation of a stroke patient, once a particular level of function has been achieved it can be maintained in spite of the sensory loss for several months after discharge and perhaps longer.

Again the patients with persistent gross sensory loss at second discharge show two opposing trends. The 2 patients who had further strokes (one died), which was the reason for their second discharge, both came from this group. Taken together, the group with gross loss on admission produced all the deaths and all the further strokes (except for one) in the 29 patients who could be checked up on at the end of the year. On the other hand, 2 patients out of the gross loss group at second discharge were still at home and independent in self-care (Rankin I and II), one year after discharge from hospital.

These findings suggest that sensory loss on admission - and persistent gross sensory loss in particular - has a poor prognosis for survival and increases the likelihood of a further stroke and poor outcome after

rehabilitation. It must be emphasised, that a hasty or premature decision about a patient's future must never be made on the basis of sensory deficit as it is still compatible with discharge home and independence in self-care.

The general picture of recovery in the study group as a whole demonstrates that maximum recovery had occurred by first discharge and out of the 18 patients who still had persistent sensory loss at that time, only 4 improved their sensory status by second discharge. Also, as can be observed in Tables 25 and 32 (pp. 90 and 98), out of the 9 patients who made a complete recovery, not one came from the gross loss group on admission.

It is not possible to draw any definite conclusions about the effect of the laterality of a stroke in this study. Many of the right hemiplegias admitted to the stroke unit were excluded from this study group because language problems made them untestable and there is no way of knowing how many of these might have had discriminative sensory loss. However, it is worthwhile noting that 8 out of the 10 right hemiplegias in the study group were in the moderate or slight loss group on admission and by first and second discharge, all 8 survivors were either in the slight loss group or had made a complete recovery.

This would indicate, as with sensory loss, that in

this particular group of strokes with a motor paresis sufficient to prevent walking, aphasia is an indication of a more extensive lesion. By rejecting these strokes with aphasia, the more severe right hemiplegias were not included in the study group which did not happen with the left hemiplegias. Gregory and Aitken (1971) who evolved tests for the assessment of parietal lobe function in hemiplegia noted that in their series, the non-dominant parietal lobe was affected twice as often as the dominant which would agree with the present study. Also, the severity of the disorder was rarely as severe in the dominant as in the non-dominant parietal lobe. However, they did not make it clear where the aphasic patient - in particular the one with severe comprehensive difficulties - fitted into their scheme of testing so it is impossible to make a strict comparison.

The Recovery of Individual Modalities

A distinct pattern can be observed by studying the number of individual modalities present in the study group on admission, first discharge and second discharge. The abilities to appreciate tickle, different textures and sizes are the modalities most likely to be spared in a partial loss of sensation and are the modalities most likely to return after a gross loss. Proprioception is more often affected than these 3 modalities but when it

does recover, a greater degree of recovery would appear to take place. Appreciation of weight, shape and two point discrimination in the affected hand are most likely to be absent in a partial loss and are always last to recover in gross loss. These characteristics are most marked in two point discrimination.

Holmes' (1927) view that in pure cortical damage the modalities served by the deeper afferents i.e. proprioception, weight and two point discrimination were most likely to be affected before those involving tactile sensibility, would fit in with these findings. Reviewing all the cases of cerebral damage which he and Head examined over the years, Holmes found that the modality most likely to be absent was weight discrimination.

Another distinctive pattern can be seen when the time of recovery of individual modalities is studied. Taking the modalities which were absent on admission but had returned to normal by first discharge in the whole study group, over 50% had recovered by one month and 80% by two months. In the group followed up over the year to second discharge, 60% had returned to normal by two months and over 75% by three months. The recovery after six months was very small and sporadic but it did occur and is difficult to explain.

Therefore, the greater part of recovery had taken place by about two months and certainly by three, which

approximately matches the rate of spontaneous recovery of motor function found by Buskirk (1954). Evans (1935) in his review of 17 cases of cerebral excisions which had a detailed sensory examination similar to that of Head and Holmes (1911) showed in a 21 year old patient with total sensory dysfunction at twenty-four hours, that recovery had taken place by thirty-eight days. Buskirk and Webster (1955) found in their study that two point discrimination recovered in an average of one and a half months. Newman (1972) found that there was a wide variation in the time of recovery of both motor and sensory function but this usually occurred between the second and third months with little neurological improvement taking place after that time. It is evident therefore that recovery, if it is going to take place, will probably occur by two months and certainly by three months after the stroke.

There is little to note in comparing the relative times of recovery of the individual modalities except that tickle and texture would appear to return earlier than the other modalities with two point discrimination always last of all. It is interesting that stereognosis and two point discrimination in the unaffected hand, if they are to recover do so in the same time scale as tickle and texture.

Stereognosis

When the highest stereognosis score gained is related to the number of modalities present at that time, two findings emerge. Firstly, it is possible to have intact stereognosis with only 4 modalities present (but not necessarily the same 4) and secondly, even if 4 modalities or more are present, there may be either a minimal stereognosis score or none at all showing gross loss of stereognosis. This would confirm the definition of stereognosis used within the context of this study, (page 2), in that there are two stages in the recognition of familiar objects. Initially there is appreciation of the physical qualities of the object and secondly, there is the integration and correlation of this perception in the higher cortical centres leading to identification. It would seem from the evidence presented that if this second component is intact, fewer modalities are perhaps required for stereognosis.

In the group with a maximum score for stereognosis, there were 7 patients who had fewer than 7 modalities and 4 of them had only 4. In this latter group, size and tickle were the only ones present in all 4 patients, the ability to discriminate shape, and weight were only normal in 2 and none had two point discrimination in the affected hand. Only one patient had normal proprioception. This together with the absence of two point discrimination

would suggest once more that neither of these modalities is essential for stereognosis. This is also demonstrated by the normal group on admission (page 71). Here, out of 40 strokes with normal stereognosis, 14 had some loss of proprioception and 9 did not have normal two point discrimination.

It could be said that normal proprioception is probably essential for normal stereognosis and it may be that the thumb finding test used in this study is not sensitive enough to determine minor degrees of proprioceptive loss. It may therefore be of interest to repeat this exercise with finer tests involving the small joints of the hands. However, after the preliminary investigation, it was felt that those tests would only be of value in younger patients with good intellectual function and concentration span. In any case, Head and Holmes (1911) commented that the appreciation of size, shape and form did not appear to depend on the appreciation of posture or passive movement.

Stereognosis would also appear not to be dependent on the ability of the hand to grasp or manipulate an object. In the group who regained normal stereognosis (13 patients), 5 still had a flaccid hand. Also, in the normal group on admission, out of 40 patients with normal stereognosis, 11 had a flaccid hand.

In patients with no stereognosis, or a less than

maximum score, generally the higher the score the greater the number of modalities present. This would appear to be logical but there were exceptions with one patient having 4 modalities with no stereognosis score and another with 7 who never achieved the maximum score for stereognosis. Texture and tickle were again shown to be the modalities most likely to be present while weight, shape and two point discrimination were most likely to be absent.

Whatever the underlying process, clinically it became clear that the patients fell into two groups - those who had instant recognition of the objects and those who had to struggle to interpret whatever sensory information was getting through to them. This instant recognition occurred in some patients who had only 4 modalities and was also striking in some who had a flaccid hand, where the patient identified the object before the examiner had even begun to manipulate it in the patient's hand. This was also noted by Head and Holmes in 2 of their patients with complete paralysis.

In the group who had 3 or more modalities and were seen to 'struggle', it was obvious that the patients were unable to correlate the sensory information they were receiving. Because of the close relationship which invariably developed between the examiner and the patient over the period of testing, the patient was encouraged to

be and usually was, quite voluble about what he was feeling with his hand and why he came to certain conclusions. This proved to be one of the most interesting parts of the study for both the patient and the examiner. For example, the patient with 6 modalities who described the orange as a round object of medium weight, moderately firm and not very smooth, called it a "haggis". Another, with 5 modalities who had been a cook all her life, identified the objects as vegetables of similar size and shape, e.g. the handkerchief was a "lettuce", the key a "leek" and the coin a small piece of "turnip". Both these patients had correctly identified the objects with their unaffected hand.

Unfortunately, no measure was taken of the time or other factors in this aspect of the study as it was not appreciated during the preliminary investigation that it would be such a distinctive feature.

In patients with maximum stereognosis scores of 3, 4 or 5 (7 in all), it is interesting to see which objects were apparently more easily recognised when these scores were gained. All 7 patients identified the handkerchief and all but one, the rope and brush. The coin was least often recognised (one patient only) perhaps because of its small size.

Two Point Discrimination

The testing of two point discrimination proved to be frustrating and difficult because it was so dependent upon patient co-operation. The results could vary from day to day and from hour to hour, justifying the comments of Adams (1966) on the difficulties in examining sensation in the elderly. The test itself can confuse even the intellectually normal patient who may retain the 'memory' of the previous prick, which can lead to more errors. It was only when assessing the results and grouping them into categories (page 47) that it could be seen that a particular patient's results were consistently in one group though the figures varied widely within the group.

The ability to distinguish between two sharp points applied simultaneously to the surface of the skin would appear to be highly dependent on normal cerebral function. With only 4 patients in the study group unaffected in either hand, this modality was found to be one of the most likely to be absent and if recovery occurred to be among the last to return. With 84% of the study group having lost the modality on the affected side on admission, 68% were still without it on first discharge and in the group followed up for a year, 40% still had a deficit. Even more remarkable was the loss on the unaffected or ipsilateral hand with 65% having lost the modality on

admission, 26% still without it on first discharge and at the end of the year, 20% of those followed up still had a deficit. It is interesting to note that the recovery which took place in the ipsilateral hand occurred in a third of the time taken by the paralysed hand.

This test demonstrated convincingly that abnormal two point discrimination can occur after stroke in the ipsilateral or unaffected hand. The other measurable test was for proprioception but the thumb finding test as such could not be carried out on the ipsilateral hand because of the paralysis of the affected hand and arm. However, all patients in the study were shown to have normal proprioception on the ipsilateral side by the finger-nose test, (page 40). The other tests carried out on the non-stroke side were to assess the patient's reliability and comprehension and not to measure defects in other sensory modalities.

It has been pointed out by Corkin et al (1970) and Carmon (1971) that an ipsilateral defect is usually missed as the measurement on the unaffected or ipsilateral side is usually taken to be the base-line for comparison and regarded as 'normal'. They emphasize the defects of this approach and also the need to evaluate the scores on the ipsilateral side, by comparing them with those in the normal population. This comparison was done for two

point discrimination in this study and the results confirm the views of these investigators that an ipsilateral defect would have been missed if the unaffected hand had been regarded normal.

Carmon reviewing the reported cases of unilateral cerebral disease with bilateral sensory defect found the number to be very small but attributed this to faulty methodology due to the assumption of normal sensation in the ipsilateral or unaffected hand. In his own cases of unilateral cerebral disease (mean age 50 years and not all were strokes), Carmon found that there was a significant impairment in the ipsilateral hand for absolute pressure threshold and two point discrimination. Corkin on the other hand found a significant impairment only in point localization, i.e. the ability of the patient to judge whether two successive stimulations were both at the same point on the palm or at two different points. Neither of these workers found evidence to support Semmes (1965) in her contention that there is an asymmetry of function between the two hemispheres as far as tactile discrimination is concerned. It was not the intention of the present investigation to compare the tactile sensory performance of the two hemispheres but the results do not point to any obvious difference in function between them so far as this is concerned.

It is difficult to speculate on the underlying

explanation for the ipsilateral defect and Corkin again pointed out that there has been very little work done in this field. One reasonable explanation would be that sensory information from the non-infarcted hemisphere is projected into the parietal lobe of the affected hemisphere and is thus influenced by it. The exact location of these fibres is still not known.

The significance of persistent loss of two point discrimination is evident. The group that retained or regained two point discrimination in both hands had almost twice the number of patients still at home at second discharge compared to the group with persistent loss which contained virtually all those who died or became long-term patients. This means that in assessing the prognosis for functional recovery after stroke, persistent loss of two point discrimination in the affected hand indicates a poor prognosis.

Lehman et al (1975) evaluated various predictors of functional outcome after stroke. In the medical data used, he included tests for touch, pain, position sense and sensory extinction but none of these were found to be of value in predicting outcome. Ben Yishay et al (1970) however, did a very detailed study into 42 psychometric parameters and found that sensory intactness as demonstrated by two point discrimination was a reliable predictor for ambulation but not so much for length of

stay or self-care. This would agree with the findings in this study as shown by the numbers who regained or retained two point discrimination who achieved home discharge.

Recovery

To attempt to explain the return of cerebral function in anatomical terms is very difficult. There is little work in this field and what there is has mainly been in younger brain damaged individuals or in experimental animals. In this study of elderly strokes, the recovery in the first hours is probably due to the return of circulation to the ischaemic area by means of a reactive hyperaemia in the territory of the obstructed vessel and that in the first few days may be explained by the resolution of the oedema surrounding damaged brain tissue and perhaps by the opening up of collateral vessels. It is more difficult to explain recovery weeks or months after the event.

Teuber (1975) investigated 520 men with known brain injuries sustained in World War II, Korea or Vietnam and found the recovery to be impressive but this was in younger subjects and there was a close correlation between recovery and age i.e. the younger the patient the greater the improvement. He found this recovery impossible to explain and in his review of the literature,

it was evident that very few attempts had been made to discover its cause. Though Teuber's group bears little similarity to elderly stroke victims, some of the theories and views put forward about the recovery of function may be applicable in future research.

The old idea that the resilience of cerebral function was due to an initial "overshoot" or "diaschisis" is now coming back in favour. Here it is considered that recovery when it does take place, is merely a recovery of depressed neuronal function and that there is no reorganisation of nervous processes. Other views of plasticity of nerve terminals where "rewiring" may account for remote effects from focal lesions, and sprouting of nerve terminals after certain cerebral lesions giving rise to epileptic attacks (not uncommon after stroke) are as yet ill-understood. Other opinions are that apparent recovery is only an adjustment by which the organism manages to get by without the function which is lost or that the function is taken over by structures not previously concerned with it.

Whatever the underlying mechanism, it is difficult to explain recovery after a stroke in the elderly brain where there is frequently generalised vascular disease. The view that the return of depressed neuronal function accounts for recovery seems a reasonable explanation in the first two to three months. It is more difficult to

understand late recovery e.g. that which occurs after six months. Any of the other theories might account for late recovery in young patients but are unlikely to be the answer in the older patient.

Whatever the explanation, and it is at present speculative, it is clear that greater knowledge of cerebral structure and its relationship to function is needed. When this is better understood, methods for hastening recovery may be found.

Clinical Value of Tests for Discriminative Sensation

The tests as described in this study would not normally be done in the general medical examination of the stroke patient. They have no place in predicting the outcome of the stroke as far as survival is concerned, but it is clear that in such a patient with no other neurological disease, these tests are reliable indicators as to the presence or absence of discriminative sensation.

Therefore, once the period of rehabilitation is entered, they would be of value in the general neurological assessment of the patient and his recovery. They may indicate why a patient who, on the face of it should be performing satisfactorily, may be having problems in the simple tasks of Activities of Daily Living (A.D.L.). If more were known about which problems in A.D.L. were associated with loss of discriminative sensation, these

tests could be used as an indicator of future difficulties in rehabilitation on the patient's admission to hospital.

Ideas for Further Research

The project has shown that patient co-operation is essential to research into disorders of perception. Any future work in this field will depend on having access to stroke patients with loss of discriminative sensation and who are fully conscious, have no disorder of language and who are intellectually and physically suitable for testing. It would be advantageous to include a number of younger patients where the incidence of generalised vascular disease is likely to be less.

If such patients were available it would be worthwhile to do the following:

1. To repeat this investigation with a more detailed assessment of intellectual function and to determine if there is any correlation between the recovery of cognition and that of discriminative sensation. If younger strokes are included, it would be easier to estimate the pre-stroke level of intellect and to relate this to their recovery.
2. To include with the individual tests a measurement of the time taken for the reply and to determine whether this correlates with the recovery of intellec-

tual function and discriminative sensation.

3. To attempt to relate the loss of discriminative sensation with particular difficulties in the activities of daily living.
4. To include tests for proprioception which are more sensitive in assessing its relationship to the ability to discriminate size and shape.
5. To determine any relationship between the recovery of discriminative sensation with the restitution of motor function in the arm and hand.

CHAPTER 12

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CHAPTER 13

APPENDIX

TABLE 37

STUDY GROUP

Patient	Sex	Age in Yrs	Side of Stroke	1st/2nd Stroke	First seen in Hours	First Sensory Exam in Days	Days in Hosp	Rankin Grade on 1st Disch	Plcemnt on 1st Disch
1. Nis	M	68	L	1st	2	15	58	IV	LT
2. Art	F	72	L	1st	10	9	92	IV	H
3. Mer	F	78	L	1st	4	6	55	II	H
4. Ada	M	87	R	1st	3	4	38	III	H
5. Boy	F	77	L	1st	4	8	15	Death	
6. Rob	F	68	R	1st	22	8	87	IV	H
7. Whi	F	72	L	1st	5	3	37	III	H
8. Beg	M	68	L	2nd	1	6	112+	IV	LT
9. Wyl	F	70	L	1st	17	4	31	III	H
10. All	M	66	R	1st	18	4	90	Further stroke	
11. Cum	M	68	L	1st	7	4	91	II	H
12. Sau	F	75	L	1st	2	3	27	II	H
13. Nor	F	82	L	2nd	19	6	47	II	H
14. Gil	M	63	R	1st	5	3	21	II	H
15. Gre	F	75	R	1st	8	7	46	Death	
16. Wal	M	69	L	1st	2	4	44	III	H

TABLE 37 (Cont)

STUDY GROUP

Patient	Sex	Age in Yrs	Side of Stroke	1st/2nd Stroke	First seen in Hours	First Sensory Exam in Days	Days in Hosp	Rankin Grade on 1st Disch	Plcemnt on 1st Disch
17. Hun	M	76	L	1st	1	5	99	II	H
18. For	F	80	L	1st	13	4	112+	I	H
19. Rei	F	72	L	1st	1	6	36	Death	
20. McM	F	66	L	1st	2	2	112+	IV	H
21. Fra	F	78	L	1st	20	8	77	IV	LT
22. Lin	F	83	L	1st	13	7	70	IV	LT
23. Glo	F	77	R	1st	1	7	99	II	H
24. Red	F	65	L	1st	3	10	111	III	H
25. Mas	M	71	R	1st	2	6	112+	III	H
26. Pal	M	62	R	1st	3	7	112+	IV	H
27. Kil	F	80	L	2nd	4	8	45	II	H
28. McG	M	81	R	1st	22	3	56	II	H
29. Rot	F	64	L	1st	50	3	23	II	H
30. Gib	F	62	L	1st	3	6	112+	III	LT
31. Hal	F	71	R	1st	4	6	70	III	H

TABLE 38

GROUP A - NORMAL STEREOGNOSIS

Patient	Sex	Age in Yrs	Side of Stroke	1st/2nd Stroke	Days in Hosp	Rankin Grade on 1st Disch	Plcemnt on 1st Disch	Grip	2 pnt Discrim Unaff mm	2 pnt Discrim Aff mm
1. Bap	F	83	R	1st	32	II	H	+	35	28
2. Cam	F	69	R	1st	44	II	H	+	10	34
3. Hod	M	76	R	1st	9	I	H	+	30	25
4. Dic	F	64	L	1st	76	IV	H	+	31	30
5. Wal	F	77	L	1st	62	I	H	-	37	32
6. Pri	M	69	R	1st	21	I	H	+	24	28
7. Swe	F	77	L	1st	68	IV	H	-	10	29
8. Con	M	69	R	2nd	9	I	H	+	34	24
9. Cam	F	61	R	1st	46	II	H	-	35	40
10. Mui	M	85	R	1st	35	II	H	-	1 pnt	44
11. Gra	F	66	L	1st	16	II	H	+	10	30
12. Gil	F	70	L	1st	39	II	H	+	29	40
13. Mur	F	68	R	1st	12	II	H	+	34	31

TABLE 38 (Cont)

GROUP A - NORMAL STEREOGNOSIS

Patient	Sex	Age in Yrs	Side of Stroke	1st/2nd Stroke	Days in Hosp	Rankin Grade on 1st Disch	Plcemnt on 1st Disch	Grip	2 pnt Discrim Unaff mm	2 pnt Discrim Aff mm
14. Chu	F	76	R	1st	10	II	H	+	1 pnt	1 pnt
15. Cla	F	65	L	1st	22	II	H	+	27	32
16. War	F	78	R	1st	22	I	H	+	1 pnt	1 pnt
17. Fai	M	77	R	1st	41	II	H	-	24	25
18. San	M	70	L	1st	22	II	H	-	30	38
19. Rei	F	75	L	1st	33	II	H	+	29	34
20. Wil	F	84	R	1st	55	II	H	+	20	20
21. Mal	F	73	L	1st	26	I	H	+	30	19
22. Woo	M	75	L	1st	19	I	H	+	46	53
23. Ken	F	75	R	1st	112+	III	H	-	1 pnt	42
24. Sco	M	74	L	1st	11	I	H	+	37	40
25. Mac	F	71	R	1st	112+	IV	H	-	44	48
26. Lum	M	69	R	1st	26	II	H	-	25	27

TABLE 39

GROUP B - NORMAL STEREOGNOSIS WITH LOSS OF PROPRIOCEPTION

Patient	Sex	Age in Yrs	Side of Stroke	1st/2nd Stroke	Days in Hosp	Rankin Grade on 1st Disch	Plcemnt on 1st Disch	Grip	2 pnt Discrim Unaff mm	2 pnt Discrim Aff mm	Proprioception (Scoring p 41) Score on Adm	Proprioception (Scoring p 41) Wks to Recov
1. Arm	F	73	R	2nd	68	II	H	+	31	22	2	3
2. McH	F	82	R	1st	25	II	H	+	20	4	2	3
3. But	F	80	R	1st	38	II	H	+	27	30	2	2
4. Men	M	64	L	1st	38	II	H	+	22	47	2	2
5. Tav	M	69	R	1st	18	II	H	+	25	52	2	1
6. Gre	M	78	R	1st	65	II	H	+	27	33	2	2
7. Ste	M	63	R	2nd	20	II	H	-	22	36	1	2
8. Coo	M	71	R	1st	16	I	H	+	25	35	2	1
9. Ogi	M	79	L	1st	15	I	H	+	31	33	2	2
10. Mun	F	78	R	1st	57	IV	H	+	35	58	2	4
11. McI	F	71	R	1st	42	II	H	+	26	25	2	1
12. Smi	M	69	L	1st	18	I	H	+	22	29	2	2
13. Shu	F	68	L	1st	47	Death		+	10	15	2	N/K
14. Gra	M	74	L	1st	86	I	H	-	35	39	2	2

TABLE 40

UNTESTABLE GROUP

Patient	Sex	Age in Yrs	Side of Stroke	Days in Hosp	Rankin Grade on 1st Disch	Plcemnt on 1st Disch	Major Reason for being Untestable
1. Lan	M	74	R	99	III	H	Aphasia
2. Can	M	64	R	61	II	H	Aphasia
3. Gib	M	61	R	68	III	H	Aphasia
4. Mor	M	83	R	19	I	H	Confusion
5. Mof	F	79	R	23	II	H	Aphasia
6. Bro	F	70	L	7	Death		Conscious Level
7. Mat	M	88	L	53	Death		Confusion
8. Wal	M	76	R	20	II	H	Aphasia
9. Bry	F	82	L	69	V	LT	Neglect
10. McE	F	67	L	1	Death		Conscious Level
11. Fra	M	70	R	112+	V	LT	Aphasia
12. Bir	F	61	R	5	Death		Aphasia
13. Dar	M	72	R	17	Death		Aphasia
14. Lam	M	66	R	28	III	H	Aphasia
15. Hes	F	76	R	28	III	H	Aphasia

TABLE 40 (Cont)

UNTESTABLE GROUP

Patient	Sex	Age in Yrs	Side of Stroke	Days in Hosp	Rankin Grade on 1st Disch	Plcemnt on 1st Disch	Major Reason for being Untestable
16. Tur	F	82	R	112+	III	H	Aphasia
17. Fin	M	72	R	112+	V	LT	Aphasia
18. Sim	F	80	L	5	Death		Conscious Level
19. Coc	F	78	L	73	V	LT	Confusion
20. War	F	73	R	58	II	H	Aphasia
21. Tho	M	76	R	93	III	LT	Aphasia
22. Bod	M	69	R	107	IV	H	Aphasia
23. Cla	M	67	R	112+	IV	H	Aphasia
24. Hyn	F	79	R	73	Death		Aphasia
25. Gil	F	74	L	18	Death		Neglect
26. Mar	M	75	L	70	Death		Confusion
27. Wed	M	77	R	44	III	H	Aphasia
28. Ram	F	62	R	41	II	H	Aphasia
29. McG	F	73	R	3	Death		Conscious Level

1. NIS

Wks frm Admiss		1	2	3	4	5	6	7	8		12	17	22
Texture			2	0	0	3	3	3	3		3	3	3
Size			0	0	0	0	2	3	2		2	0	2
Weight			0	1	1	0	2	1	0		0	0	1
Shape	NOT TESTED - SOMNOLENT		0	0	0	0	0	0	0		0	0	0
Tickle			0	0	1	1	0	0	0		1	0	0
Proprio			1	1	1	1	1	1	1		1	1	0
Two pnt Dis (A)[1]			3	1	1	1	1	2	2		1	1	1
Stereog			2	0	0	0	0	0	0		0	1	1
Grip			0	0	0	0	0	0	0		0	0	0
Two pnt Dis (U)[2]			3	3	3	1	1	3	3		1	1	1

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

NOT TESTED
MENTAL DETERIORATION
DIED 8 MONTHS AFTER STROKE.

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	-	-	-	-	0	-	+
First Discharge	+	-	-	-	-	-	-	0	-	+
Second Discharge	+	-	-	-	-	-	-	1	-	+
Weeks to Recovery	5							17		

\+ = Modality normal
\- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 1
2nd Discharge = 1

2. ART

Wks frm Admiss	1	2	3	4	5	6	7	8	9	10	11	12	13	19	24	34	38	43	48	52				
Texture	3	0	1	0	3	2	1	1	3	3	1	0	1	3	1	3	2	2	3	1				
Size	2	0	3	0	0	2	1	3	2	2	3	1	2	2	1	2	3	2	2	1				
Weight	1	0	0	0	1	1	1	0	2	1	0	0	1	3	0	2	1	0	2	1				
Shape	0	1	0	0	0	0	0	1	0	3	1	0	2	0	1	2	0	2	0	0				
Tickle	0	0	1	0	0	1	3	2	1	0	0	2	1	1	1	3	0	1	1	1				
Proprio	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	3	1	3	2				
Two pnt Dis (A)[1]	0	3	0	0	0	0	2	1	1	1	1	1	1	1	1	1	1	1	1	1				
Stereog	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0				
Grip	0	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+				
Two pnt Dis (U)[2]	2	3	1	1	2	2	1	1	1	1	1	1	1	1	1	3	1	1	3	2				

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	-	-	-	-	0	-	-
First Discharge	-	-	-	-	-	-	-	1	+	-
Second Discharge	-	-	-	-	-	+	-	1	+	-
Weeks to Recovery						38		13	2	

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 0
2nd Discharge = 1

3. MER

Wks frm Admiss	1	2	3	4	5	6	7	8	14	18	21	25	29	33	38
Texture		3	3	3	3	3	3	3							
Size		3	3	3	3	3	3	3							
Weight		3	3	3	3	3	3	3							
Shape		1	3	4	5	5	5	5							
Tickle		0	3	3	3	3	3	3							
Proprio	0	1	1	1	1	1	1	1	2	3	2	2	3	3	3
Two pnt Dis (A)[1]	1	3	3	1	1	1	1	2	3	3	3				
Stereog		2	4	6	6	6	6	6							
Grip	0	0	+	+	+	+	+	+							
Two pnt Dis (U)[2]	1	2	3	3	1	2	1	2	3	3	3				

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	+	+	+	-	-	-	-	2	-	-
First Discharge	+	+	+	+	+	-	-	6	+	-
Second Discharge	+	+	+	+	+	+	+	6	+	+
Weeks to Recovery				5	3	18	14	4	3	14

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 3
1st Discharge = 5 + stereognosis
2nd Discharge = 7 + stereognosis

4. ADA

Wks frm Admiss	1	2	3	4	5	8	15	19	23	38	52
Texture	3	2	3	3	3						
Size	3	3	3	3	3						
Weight	3	3	3	3	3						
Shape	3	5	5	5	5						
Tickle	3	3	3	3	3						
Proprio	0	1	1	2	2	1	2	2	2	3	3
Two pnt Dis (A)[1]	1	1	1	1	1	1	2	1	1	1	1
Stereog	3	6	6	6	6						
Grip	+	+	+	+	+						
Two pnt Dis (U)[2]	1	3	1	1	1	1	2	1	1	1	1

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

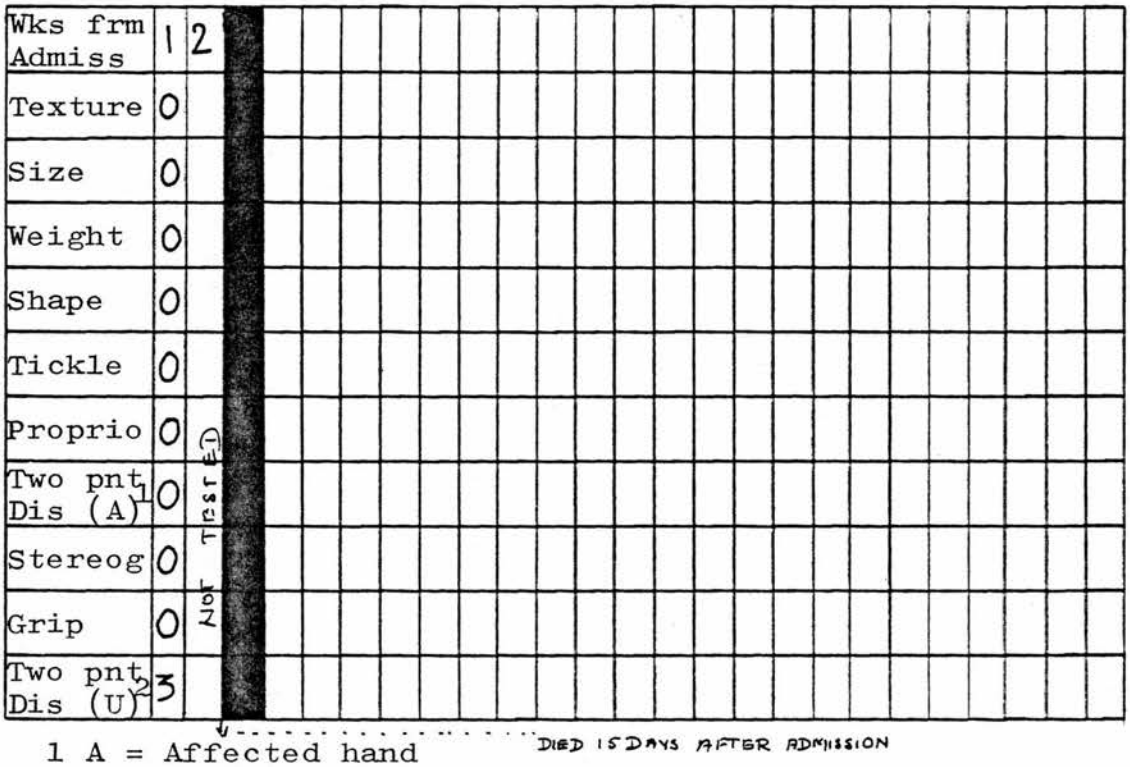
	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	+	+	-	+	-	-	3	+	-
First Discharge	+	+	+	+	+	-	-	6	+	-
Second Discharge	+	+	+	+	+	+	-	6	+	-
Weeks to Recovery	3			2		38		2		

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 3
1st Discharge = 5 + stereognosis
2nd Discharge = 6 + stereognosis

5. BOY



1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	-	-	-	-	O	-	+
First Discharge	-	-	-	-	-	-	-	O	-	+
Second Discharge										
Weeks to Recovery										

\+ = Modality normal
\- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 0
2nd Discharge =

6. ROB

Wks frm Admiss	1	2	3	4	5	6	7	8	9	10	11	12		18	22	26	30	36	41	45	51				
Texture	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3				
Size	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3				
Weight	2	1	2	2	3	2	3	3	3	2	3	1		3	3	2	3	3	3	3	3				
Shape	5	0	3	3	3	5	5	2	3	3	3	3		3	1	3	5	2	3	5	2				
Tickle	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3				
Proprio	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3				
Two pnt Dis (A)[1]	1	1	2	1	2	2	3	2	3	1	3	1		3	3	3	3	3	3	3	3				
Stereog	2	3	6	5	5	4	5	5	5	4	5	5		6	5	6	6	6	6	6	6				
Grip	0	0	0	0	0	0	0	0	0	0	0	+		+	+	+	+	+	+	+	+				
Two pnt Dis (U)[2]	1	1	3	3	3	2	3	3	3	2	3	1		3	3	1	3	3	3	3	3				

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	+	+	-	-	+	+	-	2	-	-
First Discharge	+	+	+	+	+	+	-	6	+	+
Second Discharge	+	+	+	+	+	+	+	6	+	+
Weeks to Recovery			7	6			18	3	12	3

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 4
1st Discharge = 6 + stereognosis
2nd Discharge = 7 + stereognosis

7. WHI

Wks frm Admiss	1	2	3	4	5	6	12	17	22	26	30	37	41	46	52								
Texture	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3								
Size	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3								
Weight	1	2	1	2	1	2	2	3	3	3	1	3	3	2	3								
Shape	2	2	3	3	2	3	1	3	4	2	3	4	3	3	5								
Tickle	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3								
Proprio	1	2	3	3	3	3	3	3	3	3	3	3	3	3	3								
Two pnt Dis (A)[1]	1	1	1	2	3	2	1	1	2	1	1	3	3	3	2								
Stereog	1	2	3	4	3	5	5	4	5	4	4	4	4	5	5								
Grip	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+								
Two pnt Dis (U)[2]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3								

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	+	+	-	-	+	-	-	1	+	+
First Discharge	+	+	-	-	+	+	-	5	+	+
Second Discharge	+	+	+	+	+	+	+	5	+	+
Weeks to Recovery			17	52		3	37	6		

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 3
1st Discharge = 4
2nd Discharge = 7

8. BEG

Wks frm Admiss	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	22	31	39	44	52			
Texture	0	1	2	0	3	1	0	0	0	3	3	2	0	1	1	3	2	2	2	3	1			
Size	0	0	1	1	1	0	1	0	1	1	2	3	1	0	1	3	2	1	2	2	2			
Weight	0	0	1	0	3	2	0	0	0	2	1	1	2	3	1	1	0	3	1	2	1			
Shape	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	2	2	0	1	1			
Tickle	0	0	0	2	1	1	0	0	0	1	1	3	3	0	0	0	0	0	0	1	0			
Proprio	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
Two pnt Dis (A)[1]	0	1	1	1	0	1	1	1	0	1	1	1	1	1	0	1	1	2	0	1	0			
Stereog	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0			
Grip	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	+			
Two pnt Dis (U)[2]	3	3	3	3	2	3	3	3	2	3	1	3	3	2	3	2	3	3	3	3	3			

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	-	-	-	-	0	-	+
First Discharge	-	-	-	-	-	-	-	1	-	+
Second Discharge	-	-	-	-	-	-	-	1	+	+
Weeks to Recovery								10	52	

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 0
2nd Discharge = 0

9. WYL

Wks frm Admiss	1	2	3	4	12	17	22	30	35	39	44	51											
Texture	1	3	3	3	3	3	3	3	3	3	3	3											
Size	1	3	0	3	3	3	2	2	3	2	3	2											
Weight	0	1	0	0	3	2	1	0	3	3	2	2											
Shape	0	0	0	0	1	2	1	4	2	2	3	1											
Tickle	0	3	3	3	3	3	3	3	3	3	3	3											
Proprio	1	2	2	2	2	U/T[3]	U/T[3]	2	2	U/T[3]	U/T[3]	2											
Two pnt Dis (A)[1]	1	1	1	1	1	1	1	1	1	1	1	1											
Stereog	0	1	0	1	3	3	3	1	1	1	2	1											
Grip	+	+	+	+	+	+	+	+	+	+	+	+											
Two pnt Dis (U)[2]	1	1	1	1	1	1	1	1	1	1	1	1											

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

3. UNTESTABLE due to FROZEN SHOULDER

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	-	-	-	-	0	+	-
First Discharge	+	+	-	-	+	-	-	1	+	-
Second Discharge	+	+	-	-	+	-	-	3	+	-
Weeks to Recovery	2	4			2			12		

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 3
2nd Discharge = 3

10. ALL

Wks frm Admiss	1	2	3	4	5
Texture	3	3	3	3	3
Size	3	3	3	3	3
Weight	3	3	3	3	3
Shape	5	5	5	5	5
Tickle	3	3	3	3	3
Proprio	3	3	3	3	3
Two pnt Dis (A)[1]	2	3	3	1	3
Stereog	2	6	6	6	6
Grip	0	0	0	0	0
Two pnt Dis (U)[2]	2	2	3	3	3

FURTHER STROKE. NOT TESTED.

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	+	+	+	+	+	+	-	2	-	-
First Discharge	+	+	+	+	+	+	-	6	-	+
Second Discharge										
Weeks to Recovery								2		3

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 6
1st Discharge = 6 + stereognosis
2nd Discharge =

11. CUM

Wks frm Admiss	1	2	3	4	5	6	7	8	9	10	11	12	13		17	22	27	32	38	44	49	54			
Texture	0	0	1	0	2	3	3	3	3	3	3	2	2		2	2	3	3	3	3	1	3			
Size	0	1	2	2	0	2	1	1	2	2	1	1	3		3	1	3	2	3	3	3	2			
Weight	0	1	0	1	1	1	1	0	0	1	2	3	2		2	2	0	3	1	3	2	3			
Shape	0	0	0	0	0	1	1	2	1	0	1	3	3		1	1	0	1	0	1	1	0			
Tickle	0	0	1	1	0	0	0	1	3	3	3	3	2		3	3	3	3	3	3	3	3			
Proprio	1	1	1	1	1	1	1	1	1	0¾[3]	2	3	3		3	3	3	3	3	3	3	2			
Two pnt Dis (A)[1]	0	0	0	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1			
Stereog	0	0	0	0	1	1	1	1	0	3	2	2	1		1	1	1	0	1	2	1	0			
Grip	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	+	+	+	+	+			
Two pnt Dis (U)[2]	1	3	2	3	1	2	3	2	2	3	3	3	2		2	3	3	1	3	3	3	3			

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

3. UNTESTABLE - FROZEN SHOULDER.

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	-	-	-	-	0	-	-
First Discharge	+	-	-	-	+	+	-	3	-	+
Second Discharge	+	+	-	-	+	+	-	3	+	+
Weeks to Recovery	6	38			9	12		10	32	10

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 3
2nd Discharge = 4

12. SAU

Wks frm Admiss	1	2	3	4																			
Texture	3	3	3	3																			
Size	3	3	3	3																			
Weight	2	3	3	3																			
Shape	3	5	5	5																			
Tickle	3	3	3	3																			
Proprio	3	3	3	3																			
Two pnt Dis (A)[1]	3	3	3	3																			
Stereog	5	5	5	6																			
Grip	0	+	+	+																			
Two pnt Dis (U)[2]	3	3	3	3																			

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	+	+	-	-	+	+	+	5	-	+
First Discharge	+	+	+	+	+	+	+	6	+	+
Second Discharge										
Weeks to Recovery			2	2				4	2	

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 5
1st Discharge = 7 + stereognosis
2nd Discharge =

13. NOR

Wks frm Admiss	1	2	3	4	5	6	9	13	19	23	28	34	41	47
Texture	0	1	3	0	0	1	1	2	1	3	3	2	2	0
Size	0	1	0	2	1	0	1	1	1	1	2	3	1	1
Weight	0	2	0	0	1	0	1	1	1	2	0	3	1	1
Shape	0	0	0	1	2	2	1	0	0	1	1	0	0	0
Tickle	0	2	0	0	1	1	1	1	1	2	1	1	1	0
Proprio	1	1	1	1	1	1	1	1	1	1	1	2	2	2
Two pnt Dis (A)[1]	1	1	3	2	3	1	3	3	3	3	3	2	3	0
Stereog	0	0	1	0	0	0	0	0	0	0	1	0	1	0
Grip	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Two pnt Dis (U)[2]	3	3	3	3	3	3	3	3	3	3	3	3	1	3

NOT TESTED FURTHER STROKE.

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	-	-	-	-	0	+	+
First Discharge	-	-	-	-	-	-	-	1	+	+
Second Discharge	-	-	-	-	-	-	+	1	+	+
Weeks to Recovery							9	3		

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 0
2nd Discharge = 1

14. GIL

Wks frm Admiss	1	2	3	4	7	20	29	40	52
Texture	2	3	3	3					
Size	3	3	3	3					
Weight	3	3	3	3					
Shape	5	5	5	5					
Tickle	3	3	3	3					
Proprio	2	3	3	3					
Two pnt Dis (A)[1]	2	1	1	1	2	1	1	1	1
Stereog	5	6	6	6					
Grip	+	+	+	+					
Two pnt Dis (U)[2]	2	1	1	1	2	2	2	2	2

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	+	+	+	+	-	-	5	+	-
First Discharge	+	+	+	+	+	+	-	6	+	-
Second Discharge	+	+	+	+	+	+	-	6	+	-
Weeks to Recovery	2					2		2		

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 4
1st Discharge = 6 + stereognosis
2nd Discharge = 6 + stereognosis

15. GRE

Wks frm Admiss	1	2	3	4	5	6
Texture	1	3	3	3	3	3
Size	3	3	3	3	3	3
Weight	3	2	3	2	3	2
Shape	1	5	3	3	5	5
Tickle	2	3	3	3	3	3
Proprio	1	1	1	2	2	2
Two pnt Dis (A)[1]	3	1	1	1	1	1
Stereog	2	2	6	5	5	6
Grip	0	0	0	0	0	0
Two pnt Dis (U)[2]	3	1	3	1	1	1

NOT TESTED.
DEATH — MYOCARDIAL INFARCTION.

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	+	-	-	-	-	-	2	-	-
First Discharge	+	+	-	+	+	-	-	6	-	-
Second Discharge										
Weeks to Recovery	2			2	2			3		

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 1
1st Discharge = 4 + stereognosis
2nd Discharge =

16. WAL

Wks frm Admiss	1	2	3	4	5	6		14	18	24	29	37	42	48	52										
Texture	0	3	2	3	3	0		3	3	3	3	2	2	3	3										
Size	0	1	1	3	3	2		2	3	3	3	1	2	1	2										
Weight	0	0	2	1	1	1		1	1	2	2	2	3	3	3										
Shape	0	0	0	0	3	1		2	1	3	3	5	5	4	2										
Tickle	0	2	0	0	1	1		0	2	0	2	3	3	3	3										
Proprio	0	0	1	1	1	1		3	1	3	3	3	3	3	3										
Two pnt Dis (A)[1]	1	1	1	0	1	1		1	1	1	2	1	3	1	2										
Stereog	0	0	0	0	0	0		0	2	1	2	2	2	3	3										
Grip	0	0	0	+	+	+		+	+	+	+	+	+	+	+										
Two pnt Dis (U)[2]	1	3	3	3	3	3		3	3	3	3	2	3	3	3										

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	-	-	-	-	0	-	-
First Discharge	-	-	-	-	-	-	-	0	+	+
Second Discharge	+	+	+	+	+	+	-	3	+	+
Weeks to Recovery	14	18	42	37	37	14		48	4	2

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 0
2nd Discharge = 6

17. HUN

Wks frm Admiss	1	2	3	4	5	6	7	8	9	10	11	12	13	14	18	23	29	35	40	45	51			
Texture	0	0	0	3	3	3	3	2	3				3	3	2	3	3	3	3	3	3			
Size	0	0	0	1	1	0	2	0	1				2	1	3	2	2	2	1	1	1			
Weight	0	0	0	1	2	0	2	0	1				2	0	3	0	1	1	3	3	3			
Shape	0	0	0	0	0	1	1	0	0				0	0	0	0	3	0	1	0	0			
Tickle	0	0	0	0	3	3	3	2	3				3	3	3	3	3	3	3	3	3			
Proprio	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
Two pnt Dis (A)[1]	0	0	0	2	2	2	1	2	3	3		3	2	1	3	2	3	3	3	2	3			
Stereog	0	0	0	0	0	0	0	0	0				0	0	0	0	1	0	0	0	0			
Grip	0	0	0	0	0	+	+	+	+				+	+	+	+	+	+	+	+	+			
Two pnt Dis (U)[2]	2	3	3	2	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3			

↓ PROSTATE SURGERY. NOT FULLY TESTED.

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	-	-	-	-	0	-	-
First Discharge	+	-	-	-	+	-	+	0	+	+
Second Discharge	+	-	+	-	+	-	+	1	+	+
Weeks to Recovery	4		40		5		9	29	6	5

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 3
2nd Discharge = 4

18. FOR

Wks frm Admiss	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Texture	3											3	3	3			
Size	3											3	3	3			
Weight	2											3	3	3			
Shape	1											5	5	5			
Tickle	3											3	3	3			
Proprio	2	3		3		3	2	3	3	3	3	2	2	3	3	3	3
Two pnt Dis (A)[1]	2	3		2		2	3	3	3	3	3	1	1	3	2	2	3
Stereog	1											6	6	6	6	6	6
Grip	+											+	+	+	+	+	+
Two pnt Dis (U)[2]	2	3		3		3	3	3	3	3	3	1	2	2	3	3	3

1 A = Affected hand
2 U = Unaffected hand
[redacted] = First discharge

NOT FULLY TESTED.
SURGERY - CARCINOMA OF COLON.

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Stere Score	Grip	2 pnt Dis U
Admission	+	+	-	-	+	-	-	1	+	-
First Discharge	+	+	+	+	+	+	+	6	+	+
Second Discharge										
Weeks to Recovery										

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 3
1st Discharge = 7 + stereognosis
2nd Discharge =

19. REI

Wks frm Admiss	1	2	3	4
Texture		0	2	2
Size		0	0	2
Weight		0	0	2
Shape		0	0	1
Tickle		0	0	1
Proprio	1	1	1	1
Two pnt Dis (A)[1]		0	0	0
Stereog		0	0	0
Grip		0	0	+
Two pnt Dis (U)[2]		1	3	1

DEATH - PULMONARY EMBOLUS.

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	-	-	-	-	0	-	-
First Discharge	-	-	-	-	-	-	-	0	+	-
Second Discharge										
Weeks to Recovery									4	

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 0
2nd Discharge =

20. McM

Wks frm Admiss	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	22	27	33	40	44	49	53
Texture	2	3	1	3	3		3				3	3	3	3	3	3	3	3	3	3	3	3	2	3
Size	2	2	0	1	1		3				2	3	2	3	2	2	3	3	3	2	2	3	3	3
Weight	0	0	2	0	3		0				3	1	1	3	0	1	1	1	3	2	0	3	3	2
Shape	NOT TESTED.						0				0	0	1	3	0	1	0	0	2	1	3	1	4	4
Tickle	0	0	0	0	0		2				2	3	3	3	3	3	3	3	3	3	3	3	3	3
Proprio	1	1	1	1	1	1	2				2	3	3	3	3	3	3	3	3	3	3	3	3	3
Two pnt Dis (A)[1]		0	1	0	1	1	1				1	1	1	1	1	1	1	1	1	1	1	1	1	1
Stereog	4	0	0	0	0		0				0	0	0	0	0	1	0	0	0	1	1	1	1	1
Grip	0	0	0	0	0		0				+	+	+	+	+	+	+	+	+	+	+	+	+	+
Two pnt Dis (U)[2]		1	1	1	3	1	1				1	1	1	3	1	1	1	1	1	1	1	1	1	1

NOT FULLY TESTED. EYE SURGERY.

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	?	-	-	-	0	-	-
First Discharge	+	+	-	-	+	+	-	1	+	-
Second Discharge	+	+	-	-	+	+	-	1	+	-
Weeks to Recovery	4	17			12	12		16	11	

\+ = Modality normal
\- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 4
2nd Discharge = 4

21. FRA

Wks frm Admiss	1	2	3	4	5	6	7	8	9	10	15	21	25	31	36	41	47	52
Texture	0	0	0	0	0				1	2	1	0	0	1	3	3	3	2
Size	0	0	0	3	1				2	3	3	3	3	1	2	3	2	2
Weight	0	0	0	2	3				1	2	3	1	2	2	2	3	0	1
Shape	0	0	0	0	0				0	0	1	0	0	0	0	1	0	0
Tickle	0	2	3	3	3				3	3	3	3	3	3	3	3	3	2
Proprio	1	1	1	2	2	3	3	3	3	3	2	3	3	2	3	3	2	3
Two pnt Dis (A)[1]	0	1	1	1	1	2	1	1	1	3	1	1	1	1	1	1	1	1
Stereog	0	0	0	0	0				0	0	0	0	0	0	0	0	0	0
Grip	0	0	0	0	0				0	0	0	0	+	+	+	+	+	+
Two pnt Dis (U)[2]	1	1	1	1	1	2	1	1	3	3	3	1	1	1	2	1	1	1

NOT FULLY TESTED - UNWELL.

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	-	-	-	-	0	-	-
First Discharge	-	+	-	-	+	+	-	0	-	+
Second Discharge	+	+	-	-	+	+	-	0	+	+
Weeks to Recovery	36	10			3	6			25	9

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 3
2nd Discharge = 4

22. LIN

Wks frm Admiss	1	2	3	4	5	6	7	8	9	10	15	20	25	31	36	41	46	51						
Texture	3	2	3	3	3				3	3	3	3	2	3	3	3	3	3						
Size	3	3	2	3	3				3	3	3	3	3	3	3	3	3	3						
Weight	1	0	1	3	1				1	3	3	3	3	3	3	3	3	3						
Shape	NOT TESTED				BLIND.																			
Tickle	0	3	3	3	3				3	3	3	3	3	3	3	3	3	3						
Proprio	1	1	1	1	2	3	3	2	2	2	1	3	3	2	3	3	3	3						
Two pnt Dis (A)[1]	1	2	2	3	1	2	3	3	1	3	2	2	2	3	3	3	3	3						
Stereog	0	1	1	1	1				0	1	2	1	1	1	2	1	1	2						
Grip	0	0	0	0	0				0	0	0	0	0	0	0	0	0	0						
Two pnt Dis (U)[2]	1	3	3	3	2	2	3	3	3	3	3	3	3	3	3	3	2	3						

↓ ..... ↓ NOT FULLY TESTED.

1 A = Affected
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	?	-	-	-	0	-	-
First Discharge	+	+	+	?	+	+	-	1	-	+
Second Discharge	+	+	+	?	+	+	+	2	-	+
Weeks to Recovery	3	4	10		2	6	31	15		2

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 5
2nd Discharge = 6

23. GLO

Wks frm Admiss	1	2	3	4	5	6	7	8	9	10	11	12	13		18	22	28	33	39	43	47				
Texture	2				3	3	3	3	3	3	3	3	3		3	2	3	3	3	3	3				
Size	2				3	3	3	2	1	3	3	3	3		3	3	3	1	2	3	3				
Weight	1				2	2	3	3	3	3	3	2	2		3	3	3	3	3	3	3				
Shape	5				4	3	4	5	3	5	2	5	3		3	4	5	4	3	5	5				
Tickle	3				3	2	3	3	3	3	3	3	3		3	3	3	3	3	3	3				
Proprio	1	3	2	3	2	2	2	3	3	3	3	3	3		1	3	3	2	3	3	3				
Two pnt Dis (A)[1]	1	2	2	1	2	1	3	1	1	1	1	2	2		3	2	3	3	3	2	3				
Stereog	3				1	1	4	3	1	2	3	3	2		2	2	4	5	3	3	4				
Grip	0				0	0	0	+	+	+	+	+	+		+	+	+	+	+	+	+				
Two pnt Dis (U)[2]	3	3	3	1	2	3	3	1	2	1	2	3	2		3	2	3	3	3	3	3				

NOT FULLY TESTED

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	-	-	-	-	1	-	+
First Discharge	+	+	+	+	+	+	-	4	+	+
Second Discharge	+	+	+	+	+	+	+	5	+	+
Weeks to Recovery	5	5	7	8	7	2	28	33	8	

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 6
2nd Discharge = 7

24. RED

Wks frm Admiss	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		19	24	30	35	40	44	49	52	
Texture		3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	
Size		2	3	1	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	
Weight		1	1	1	1	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	
Shape		3	2	1	0	4	5	2	2	3	5	4	5	5	5		4	5	5	5	5	5	5	5	
Tickle		3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	
Proprio	1	1	1	1	1	1	2	2	2	2	3	3	2	2	2		U/T[3]	3	2	3	2	3	3	3	
Two pnt Dis (A)[1]	3	1	1	1	1	2	1	2	3	3	2	2	3	3	3		3	3	2	3	3	3	3	3	
Stereog		1	0	1	2	1	1	0	1	3	4	5	4	4	4		4	4	5	4	5	5	3	3	
Grip		0	0	0	0	0	0	0	0	0	0	0	0	+	+		+	+	+	+	+	+	+	+	
Two pnt Dis (U)[2]	3	2	3	2	3	3	2	3	3	3	2	3	3	3	3		3	3	3	3	3	3	3	3	

3. UNTESTABLE – PAINFUL SHOULDER

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	+	-	-	-	+	-	-	0	-	-
First Discharge	+	+	+	+	+	+	+	5	+	+
Second Discharge	+	+	+	+	+	+	+	5	+	+
Weeks to Recovery		5	6	7		11	13	12	14	8

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 2
1st Discharge = 7
2nd Discharge = 7

25. MAS

Wks frm Admiss	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18							
Texture		3	3	3	2	3	3	3	3	3	2	3	3	3	3	3	3	3							
Size		2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3							
Weight		3	3	2	3	1	3	3	3	2	3	3	3	2	3	2	3	3							
Shape		0	3	5	3	5	5	5	5	5	5	5	5	4	5	3	5	5	5						
Tickle		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3							
Proprio	1	0	1	1	$\frac{3}{4}$	$\frac{4}{4}$	$\frac{4}{4}$	$\frac{4}{4}$	$\frac{4}{4}$	$\frac{4}{4}$	3	3	3	3	3	3	3	3							
Two pnt Dis (A)[1]	1	1	1	1	3	3	2	1	1	2	1	2	2	3	3	2	3	3		3					
Stereog		0	1	2	1	3	2	2	2	5	4	4	4	5	6	6	6	6							
Grip		0	0	0	0	0	0	0	0	0	0	0	0	0	0	+	+	+							
Two pnt Dis (U)[2]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3							

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

3. UNTESTABLE - PAINFUL SHOULDER

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	+	-	-	-	+	-	-	0	-	+
First Discharge	+	+	+	+	+	+	+	6	+	+
Second Discharge										
Weeks to Recovery		3	7	4		11	17	15	16	

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 2
1st Discharge = 7 + stereognosis
2nd Discharge =

26. PAL

Wks frm Admiss	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16								
Texture	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3								
Size	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3								
Weight	3	2	3	3	3	3	3	2	3	3	3	3	3	3	3	3								
Shape	2	2	5	5	4	5	5	5	5	5	5	5	5	5	5	5								
Tickle	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3								
Proprio	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3								
Two pnt Dis (A)1	1	2	1	1	1	3	3	3	3	3	1	3	2	3	3	3								
Stereog	1	5	2	5	5	4	6	6	5	5	6	6	6	6	6	6								
Grip	0	0	0	0	0	0	+	+	+	+	+	+	+	+	+	+								
Two pnt Dis (U)2	3	2	3	3	3	3	1	3	3	3	3	2	3	3	3	3								

CARCINOMA OF BLADDER — RADIOTHERAPY

IN HOSPITAL FOR SOCIAL REASONS

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	+	-	-	+	+	-	1	-	-
First Discharge	+	+	+	+	+	+	+	6	+	+
Second Discharge										
Weeks to Recovery	2		3	3			6	7	7	3

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 3
1st Discharge = 7 + stereognosis
2nd Discharge =

27. KIL

Wks frm Admiss	1	2	3	4	5	6
Texture		3	3	3	3	3
Size		3	3	3	3	3
Weight		3	3	3	3	3
Shape		5	5	5	5	5
Tickle		3	3	3	3	3
Proprio	3	3	3	3	3	3
Two pnt Dis (A)[1]	3	3	3	3	3	3
Stereog		4	6	6	6	6
Grip		+	+	+	+	+
Two pnt Dis (U)[2]	3	3	3	2	3	3

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	+	+	+	+	+	+	+	4	+	+
First Discharge	+	+	+	+	+	+	+	6	+	+
Second Discharge										
Weeks to Recovery								3		

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 7
1st Discharge = 7 + stereognosis
2nd Discharge =

28. McG

Wks frm Admiss	1	2	3	4	5	6	7	8															
Texture	3	3	3	2	3	3	3	3															
Size	3	3	3	3	3	3	3	3															
Weight	3	3	3	2	3	3	3	3															
Shape	5	4	5	4	5	5	5	5															
Tickle	2	3	3	3	3	3	3	3															
Proprio	2	2	3	3	3	3	3	3															
Two pnt Dis (A)[1]	3	3	3	3	3	3	3	3															
Stereog	4	5	6	6	6	6	6	6															
Grip	+	+	+	+	+	+	+	+															
Two pnt Dis (U)[2]	3	3	3	3	1	3	3	3															

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	+	+	+	-	-	-	+	4	+	+
First Discharge	+	+	+	+	+	+	+	6	+	+
Second Discharge										
Weeks to Recovery				3	2	3		3		

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 4
1st Discharge = 7 + stereognosis
2nd Discharge =

29. ROT

Wks frm Admiss	1	2	3	4																				
Texture	3	3	3	3																				
Size	3	3	3	3																				
Weight	1	3	2	3	3	3																		
Shape	5	5	5	5																				
Tickle	3	3	3	3																				
Proprio	3	3	3	3																				
Two pnt Dis (A)[1]	3	3	3	3																				
Stereog	4	5	5	6																				
Grip	0	0	0	0																				
Two pnt Dis (U)[2]	3	3	3	3																				

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	+	+	-	+	+	+	+	4	-	+
First Discharge	+	+	+	+	+	+	+	6	-	+
Second Discharge										
Weeks to Recovery			4					4		

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 6
1st Discharge = 7 + stereognosis
2nd Discharge =

30. GIB

Wks frm Admiss	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16							48	52
Texture	0	0	0	2	0	0	0	0	0	3	2	2	1	0	0	1								
Size	0	0	0	0	0	0	0	0	2	2	2	0	1	1	1	1								
Weight	0	0	0	0	0	0	0	0	3	2	2	2	2	1	2	0								
Shape	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0								
Tickle	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0								
Proprio	0	0	1	1	1	1	1	1	1	2	3	2	3	3	3	3								
Two pnt Dis (A)[1]	0	0	0	0	0	0	0	1	0	0	0	0	1	1	1	1							1	1
Stereog	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Grip	0	0	0	0	0	0	0	0	0	0	+	0	+	+	+	+								
Two pnt Dis (U)[2]	3	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3							3	3

1 A = Affected hand
2 U = Unaffected hand
■ = First discharge

↓ DEPRESSION. UNTESTABLE BECAUSE OF PSYCHIATRIC REASONS.

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	-	-	-	-	0	-	-
First Discharge	-	-	-	-	-	+	-	0	+	+
Second Discharge										
Weeks to Recovery						11			11	3

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 0
1st Discharge = 1
2nd Discharge =

31. HAL

Wks frm Admiss	1	2	3	4	5	6	7	8	9														
Texture	3	2	2	3	3	3	3	3	3														
Size	3	3	2	2	3	1	2	3	3	3													
Weight	3	3	2	3	3	3	3	3	3														
Shape	3	2	2	1	0	0	0	3	2														
Tickle	3	3	3	3	3	3	3	3	3														
Proprio	1	1	1	1	2	1	2	3	2														
Two pnt Dis (A)[1]	3	3	3	3	3	3	3	3	2														
Stereog	1	1	0	1	2	2	1	2	4														
Grip	0	0	0	0	0	0	0	0	0														
Two pnt Dis (U)[2]	1	3	2	2	3	3	3	3	3														

1 A = Affected hand ↓ ··· MOVED AWAY
2 U = Unaffected hand NOT FOLLOWED UP
■ = First discharge

Modalities present on Admission, First and Second Discharge

	1 Tx	2 Sz	3 Wt	4 Sh	5 Tkl	6 Pro	7 2 pnt Dis A	Max Stere Score	Grip	2 pnt Dis U
Admission	-	-	-	-	+	-	+	0	-	-
First Discharge	+	+	+	-	+	+	+	4	-	+
Second Discharge										
Weeks to Recovery	4	8	4			8		9		5

+ = Modality normal
- = Modality abnormal or absent

Summary (Modalities 1-7)

On Admission = 2
1st Discharge = 6
2nd Discharge =

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